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# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

## (Nuclear Energy, Magnetic Fusion, Small Hydro, Electric Energy and Energy Storage Systems)

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# HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND PRODUCTION

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS
FIRST SESSION

FEBRUARY 25, 26; MARCH 3, 4, 5, 10, 16, 17, 18, 19 AND 20, 1981

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*On assignment to Budget Committee for 97th Congress.

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# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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WEDNESDAY, FEBRUARY 25, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 10 a.m., in room 2325, Rayburn House Office Building, Hon. Marilyn Lloyd Bouquard (chairman of the subcommittee) presiding.

Mrs. Bouquard. The Energy Research and Production Subcommittee will come to order.

Good morning, ladies and gentlemen.

The Subcommittee on Energy Research and Production welcomes you to our very first hearing on the Department of Energy's fiscal year 1982 budget.

As most of you realize, we will not be receiving specific budget figures from the DOE on nuclear fission and fusion programs until March 10. However, we must report the budget estimates to the Budget Committee of the House by March 20. So this means that this subcommittee must complete markup on the DOE request before March 18. Because of the circumstances, we will be holding hearings with the outside witnesses to identify the major issues with which the subcommittee must deal.

This morning we expect to hear the Department's perception of the major fission and fusion issues. As you know, the magnetic fusion program is the responsibility of the Office of Energy Research, and, as I understand it, this will be the case under the DOE reorganization.

I hope that there will be a good attendance by members of the subcommittee and that they will be active in the proceedings. Many of the issues, of course, are technically complex, and the testimony by outside witnesses will serve to raise the right questions about the technologies, as well as provide a forum for outside views of the DOE program.

I am looking forward to a series of hearings on programs under jurisdiction of the subcommittee. I think it should be a refreshing change to have the administration support the nuclear option. I know it will be for me, and I believe that we have the opportunity to move ahead with the breeder reactor, reprocessing, and high level waste management programs in fiscal year 1982. I am hoping that Mr. Gates will give us some hints as to what the administration is doing in regard to developing specific funding requests.

As I told Secretary Edwards yesterday, and as Mr. Gates notes in his testimony, we must all pull together and move these programs, and I'm sure that we will give all these programs a very close look. Mr. Pewitt has generally outlined what is coming down the pike in fusion, and I think that we can expect some disappointments in requests, and believe that the subcommittee will have to sort out the options on the project funding. We'll just have to see if the DOE has the same priorities as our committee when we get the March 10 submission.

I do want to welcome Mr. Gates, Acting Assistant Secretary for Nuclear Energy, as well as Mr. Pewitt, Acting Director, Office of Energy Research. We look forward to hearing their overview of the Department's programs.

Mr. Gates, would you please proceed with your testimony.

## STATEMENT OF MAHLON E. GATES, ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY, ACCOMPANIED BY SHELDON MEYERS, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR WASTE MANAGEMENT, AND THOMAS A. DILLON, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR REACTOR PROGRAMS

Mr. Gates. Thank you, ma'am.

Madam Chairman and members of the subcommittee, I am pleased to appear before you today to discuss the Department of Energy's fission energy program. My permanent assignment with the Department is as Manager of the Nevada Operations Office, and it has been my pleasure in the past to have escorted some of the members of this subcommittee through our facilities at the Nevada Test Site. I am currently acting, on an interim basis, as the Assistant Secretary for Nuclear Energy. As such, my remarks today will be directed toward an overview of nuclear policy. More detailed information will be provided by my Deputy Assistant Secretaries in the subsequent hearings before this committee. I am accompanied today by, on my right, Dr. Thomas Dillon, Deputy Assistant Secretary for Nuclear Reactor Programs, and, on my left, Mr. Sheldon Meyers, Deputy Assistant Secretary for Nuclear Waste Management.

Decisions are still being made regarding the Department's nuclear energy program. However, in order to provide a frame of reference for the Department's strategy, I would like to reflect briefly on the paradoxical situation that exists today with regard to nuclear power development. Authoritative energy studies have repeatedly told us that nuclear energy must make an essential contribution to our energy supply. This means that nuclear's contribution must expand considerably from its current level if it is to fulfill its envisioned role as one of the principal fuel sources capable of reducing our dependence on foreign oil.

Seven years after the end of the oil embargo of 1973–74, about half of the U.S. energy consumption is still supplied by oil, our least abundant domestic energy resource. Approximately 40 percent of that oil is imported at continuously rising prices and from potentially unstable sources. An abundant resource, uranium, with a potential energy content many times that of all domestic fuels combined, accounts for less than 4 percent of current U.S. energy usage.

The nuclear industry, which was thriving and expanding in the early 1970's, has been brought to its knees, with expansion throttled, key initiatives stalled, international partnerships disrupted, and public apprehensions aggravated. The immediate promise and future potential of this abundant energy source has been threatened.

About 70 commercial nuclear powerplants—with a capacity of over 50,000 electrical megawatts—are providing 11 percent of U.S. electric power requirements. More than 25 percent of the energy generated in each of 13 States is from nuclear power and in two of those States more than 50 percent is from nuclear. This electricity, if produced by oil-fired plants, would require the annual consumption of about half a billion barrels of oil. This amounts to 1.4 million barrels of oil per day, which is roughly equivalent to the capacity of the Alaskan pipeline. However, we now have a situation in the nuclear market whereby we have had no new plant orders in the last 3 years. An additional dismaying fact is the steadily mounting number of plants that are being canceled.

The reasons for this stagnation are institutional rather than technical. Despite the fact that utilities in many areas have consistently reported lower generating costs for their nuclear units than for their fossil units, nuclear investment has not been an inviting prospect for utility executives over the last several years. A licensing process that condones excessive, redundant intervention has helped exaggerate normal market uncertainties by continuously lengthening the time required to bring a plant on line. Though the licensing process is not the sole reason, nuclear plants now take 10 to 14 years to site, design, license or permit, and construct; a decade ago such actions could be accomplished in 5 to 6 years. The hesitation to put money into a plant that has a leadtime of 10 to 14 years is understandable.

A further deterrent to nuclear development has been the perception of uncertain interest at the Federal level. Many view recent Government policies as ambivalent, if not actually hostile, toward nuclear energy. The deferral of breeder demonstration and commercial reprocessing has been interpreted as an attempt to curtail the significance of future nuclear impact. All of these factors have contributed to the earlier cited erosion of the nuclear industry and disruption of international partnerships. This must be stopped if we are to avoid the possible consequences of inadequate electrical energy, including widespread economic hardship, continued reliance on uncertain supplies of foreign oil, and increased peril to our national security.

The revitalization of the nuclear option will not be automatic nor will it come overnight. The havoc that has been wreaked is too extensive now to be undone by words alone. Only new Government policies and programs can begin to turn the situation around and return confidence to industry, to the public, and to the investors. The revitalization of our nuclear energy program has implications, not only for energy security and international solidarity with our energy allies, but also directly for production of defense materials and maintenance of our strategic nuclear deterrent. Clear statements of affirmative policy by Government leadership are the first steps for initiating action.

The problems to be addressed are both near-term and long-range. The troubles plaguing the current light water reactor industry must be resolved. But the solutions to these problems must be accompanied by responsible and timely planning for the breeder as the next generation of nuclear technology.

I would like to highlight some of the options available for a rebirth of the light water reactor industry. In the area of safety, we have a twofold responsibility. We must, of course, continue to insure the availability of technology which will permit the safe construction and operation of nuclear plants. Nuclear power already has a safety record unparalleled in any other energy industry, but despite that record an appreciable segment of the population continues to have significant concerns. Another responsibility is to insure public understanding. As a case in point, the accident at Three Mile Island, uninvited though it was, taught us lessons which, when incorporated in plant design and operation, will reduce even further the already low probability of nuclear accidents. The lessons learned and the continued output of our safety research and development activities will assure that nuclear energy will remain among our safest energy supply options. A corollary effort is needed to inform the people of the safety improvements that have been achieved. The whole area of communicating accurate information about nuclear energy to the public is one in which the Department should take the lead. It is an area where our efforts have been constrained. It's time we get on with the job.

Another option for reinforcing the light water reactor industry is in the area of regulatory reform. I understand that the Nuclear Regulatory Commission is working on some initiatives to improve the licensing system, and I heartily concur in the need for such action. In my opinion, the current process could be appreciably shortened without any sacrifice to safety considerations. Unless we do see effective reform, it is most unlikely that we will be able to attract a renewal of utility investment. Another obstacle to nuclear commitments—according to many, the key obstacle—is the difficulty facing utility financial officers as they plan for capacity additions. The general practice seems to be for utilities to buy what they can afford, not what they need. According to utility executives, public utility commissions, operating under very short-term policy horizons, are not providing the kinds of rate relief that would encourage cost-effective investments to produce the energy needed for the Nation's security.

A third and exceedingly important area requiring additional focus and attention is waste management. Indications are that this is the greatest single concern of the American public regarding nuclear energy. We already have the technology in hand or under development for safe disposal of nuclear wastes. It is my opinion that we are losing credibility with the American public by our insistence on endless studies of the problem. The commercial waste program is under review as part of a broader program to determine what is needed to shore up our nuclear programs.

The actions that I previously described are designed to reaffirm the current generation of nuclear energy, since a prerequisite to a successful advanced nuclear program for tomorrow is a strong and effective nuclear industry today. We have a viable solution to our future energy needs in the form of the breeder reactor. Moreover, unlike some other inexhaustible sources of energy supply, breeder technology does not await a scientific breakthrough. The technology is in hand and now requires program implementation. It is time to act now, while we still have the capability, the expertise, and the facilities to do it.

As you know, the liquid metal fast breeder reactor program has been stalled since 1977 with a large and expensive R. & D. program. But an R. & D. program must be focused and scheduled by a central line of advance. That is, it must be relevant to and driven by a sequence of plant projects which determine the scalability of the technology up to the size of commercial applicability. Such was the intention when project planning for the Clinch River breeder reactor began around 1969. The obstacles that have confronted CRBR over the last 10 years, however, have been continuous and severe—bad press, constant intervention, schedule slippages, and inflationary costs—to name a few. Since 1977, the licensing process for the project has been suspended. Although component fabrication has continued, the Clinch River breeder reactor has not benefited from NRC review and approval. The impasse over the last 4 years has resulted in a project that is off baseline cost and schedule. To reorient CRBR as a successful venture will require the firm resolve of this body, the administration, and the industry. On this score, let us hope that some methodology may be found to make sure that earlier efforts with the NRC on breeder licensing will not have been in vain.

As you are aware, the Department is in the final stages of its conceptual design study for a breeder that is one step beyond the Clinch River breeder reactor. The results of this study will be presented to the Congress next month.

What we gain from a breeder demonstration is the benefit that derives from the availability of a proven concept. We now have an opportunity to work toward the development of a strong industrial base in the United States for fast breeder technology. We know our allies would welcome collaboration in this endeavor.

Consistent with resumption of the breeder development program is the requisite fuel cycle development. The Government's presence in this activity is currently under intensive review within the administration.

Finally, the immediacy of the problem of cleanup and remedial actions to be taken at Three Mile Island cannot be overstated. Technical problems associated with the cleanup appear to be solvable. The matter of Federal assistance is still unresolved and is part of a larger review to determine, among other things, the disposition of the radioactive waste produced by the cleanup and the damaged reactor core. Firm and stable regulatory criteria, along with a commitment to solve this problem, must be established so the cleanup can proceed. The Department will diligently seek the best way to participate with all agencies concerned in the most helpful way possible.

Madam Chairman, I have tried to share with you this morning some of the major thrusts and priorities that are being weighed by this administration which affect the nuclear option. Decisions are still to be made regarding many of the areas that will impact nuclear development; and I'm sure that before the final policy evolves there may be compromises and shifts in emphasis. I am equally confident, however, that the underlying intent of all our efforts will remain the same—to address forthrightly those issues that are seriously limiting the nuclear option. If we succeed, the fruits of our efforts will be to achieve both the current promise and the future potential of nuclear power as a safe, clean, abundant, and reliable source of energy for this country and the world.

With the understanding that there are still a number of variables and unknowns in our program plans, I will be glad to try to answer any questions you might have.

Mrs. BOUQUARD. Thank you very much, Mr. Gates, for your very valuable testimony.

At this time I would like to recognize the ranking Republican member of the subcommittee, the Honorable Manuel Lujan.

Mr. LUJAN. Thank you, Madam Chairman. I just want to welcome you to the committee.

Mr. GATES. Thank you, sir.

Mr. LUJAN. I haven't seen you for a good while. It's good to have you here.

Mr. GATES. Good to see you again.

Mr. LUJAN. I'll use all those nice words before I get to the questions. But we see things pretty much eye to eye, as you know. I just wanted to say welcome.

Mr. GATES. Thank you very much.

Mr. LUJAN. Thank you.

Mrs. BOUQUARD. I really think that your statement on page 8 is a key one: "To reorient CRBR as a successful venture will require the firm resolve of this body, the administration, and the industry," and I hope that we can make sure that earlier efforts with the NRC on breeder licensing will not have been in vain. So it is very good to have mutual goals and commitments as we do develop a sound energy policy.

Another key word in your testimony to me, Mr. Gates, was "credibility." I think it is not only time that we reestablish our credibility with the industry so that we can go ahead and renew our commitment to complete the fuel cycle and signal to industry that they can, indeed, move forward and streamline our licensing procedures in our waste management programs and reprocessing.

I think it is also very important that we renew our credibility to our allies that we are indeed a country that is accountable for our programs, and we are not only concerned about the energy issues, the energy needs, the energy programs for our country but for the entire world and that we are indeed committed to a safe, reliable and environmentally acceptable energy program, which certainly includes our nuclear program.

Can the Department project the needs of the breeder based program over the next several years to complement the construction efforts?

Mr. GATES. I think, ma'am, that the light water reactor itself will provide an abundant source of nuclear energy for a number of years. If we are successful in bringing that program back to life and reaching fruition of the potential that it gives us, then the length of time that it can continue to provide that source of energy is limited, and, therefore, the continuation of fast breeder technology is necessary to pick up when the light water reactor dims.

Mrs. Bouquard. Thank you.

What do you feel is the critical path for the construction of the Clinch River Breeder Reactor? Do you see this as a followup step, or what do you see as the direction that we will follow in renewing our commitment and going ahead with our program?

Mr. Gates. It seems to me that the Clinch River Breeder Reactor is a logical step in the progression from the earlier experimental breeders to the point of commercialization of the breeder. I think it is the logical next step. I think it will be succeeded in some years by the product of activity that is now under way, which we refer to as the conceptual design stage for the large prototype breeder reactor.

Mrs. Bouquard. Mr. Meyers, do you have any comments you would like to make?

Mr. Meyers. Not on that program, ma'am.

Mrs. Bouquard. Is the key measure of success of the program the successful demonstration of the breeder technology, or is it to establish, do you feel, the capability to commercialize the breeder reactor? What is the ultimate goal, in your estimation?

Mr. Gates. I don't think we look at the Clinch River reactor as prototypic of a commercial reactor. It's a step up the ladder. It's at a constrained level, a midlevel, if you will, and will be very important in the scaling up of the total technology. It will be valuable in helping to establish fast breeder technology in the United States and will be valued as an R. & D. tool as we progress up the ladder to the commercial scale.

Mrs. Bouquard. Do you expect the Federal Government to fully fund the next plant, or what role do you see the utilities or industry playing in the development of the next plant?

Mr. Gates. I believe that the program can only be developed in concert with industry. I believe that it is important in this effort also to have partnerships or, indeed, relationships with our international friends, and I think it's the concert between the American industry, the American Government and other governments that will help bring this technology to fruition. I think the bottom line of what we hope to do is to establish in the United States a solid base for breeder technology.

Mrs. Bouquard. What do you see as our role in international cooperation? What do you think the links are, for instance, in our proposed plan of working with Great Britain?

Mr. Gates. I think those matters, ma'am, are still under discussion. I don't know that any final decisions have been made. But I think there is a potential not only for exchange of technology, but also perhaps for financial cooperation.

Mrs. Bouquard. One final question.

What role do you perceive the administration sees for private industry to play in fuel reprocessing at recycling facilities?

Mr. Gates. I believe at the present time the reprocessing of fuel must be a Federal responsibility, until we can reestablish, or establish, indeed, a reprocessing capability. I think it would be premature today to expect private industry to undertake that risk and that responsibility.

Mrs. **Bouquard**. Do you anticipate completion of the Barnwell plant?

Mr. **Gates**. I think that would be fortuitous. That matter, Mrs. Bouquard, is still under discussion within the administration. But we see many advantages if we could acquire the Barnwell facility. Some of those advantages include an advance in time. The Barnwell facility is about 80 percent complete, and we feel with a sizeable, yet overall, a modest investment that plant could be completed and play a significant role in our reprocessing and our closing of the fuel cycle.

Mrs. **Bouquard**. Thank you very much.

Mr. Lujan.

Mr. **Lujan**. Thank you.

I have several subjects that I want to cover, so I'm just going to go a little quickly through them.

Probably the biggest concern is something that you alluded to in your statement, and that is our whole nuclear posture.

I was in Mexico last week. They're going to buy 20 reactors in the next 20 years. Two of them are going out for bid in March, I believe. I talked to the people who are going to be in charge of ordering them, and their feeling is that the United States isn't even in the running, primarily because of our nonproliferation policies, and I think that one of the things that we really have to look at is cutting off exporting of our nuclear technology because of the policies, and we have to just turn those around. What they told us is they don't mind dealing through IAEA, but when it comes to bilateral agreements, where one nation is going to impose their views on another one, that's where the whole show stops, and we are just out of the running unless we change that.

Even Taiwan, which had representatives at that conference, the Pacific Basin Conference, is disgruntled, even though it bought all its reactors from us. But we made Taiwan dismantle its reprocessing plant that had started to operate and if there's any messsage that I can leave with DOE it's to look at the Nuclear Nonproliferation Treaty and make some changes, deal through the international agencies that are there. I think that's most important.

Mr. **Gates**. I agree with that, sir.

Mr. **Lujan**. Thank you.

On regulation, how much dialog is there betweeen DOE and NRC? I know that they were separated. But it seems to me that, with the attitude that you've expressed, part of the big problem is the whole Nuclear Regulatory Commission process, with example after example of plants ready to go on line and because, I guess, there's a lot of dissension within the Commission itself nothing moves.

What cooperation is there?

Mr. **Gates**. There is an abundant and a continuing dialog and relationship between the Department of Energy and the Nuclear Regulatory Commission. We have some 130 or 140 personnel from many of our laboratories who are currently assigned to the NRC, the purpose of which is to help them on a case-by-case basis in evaluating various and sundry activities in which they are engaged relative to the regulatory process. In correspondence we exhort them from time to time to get on with improving and shortening the licensing program. So there is a continuing relationship, and we are mindful of their problems, and hope to help them resolve those problems.

Mr. LUJAN. We sure exhort them to do the same thing. But I guess we're not any more successful than DOE is.

The WIPP project, you know. What happened immediately—I guess it was previous to the first day or the second day of the new administration—conversations had been going on with the State of New Mexico, to work out all the different problems, to get an agreement with the State. The first day DOE announced, "We're proceeding with WIPP," no matter what the outcome of discussions are. Everyone felt it was rather insensitive. We've all agreed that the States ought to play some kind of a role in the agreements, that DOE ought to take their feelings into consideration, and because of that DOE whipped up a bunch of opposition that wasn't needed. But I just want to point that out that in this particular instance more opposition than was necessary resulted from moving ahead so quickly and saying, "Well, I know we're in the middle of negotiations, but we're going to do it, anyway." That caused problems.

In regard to reprocessing, the Barnwell plant is sitting there. Any thought of acquiring it?

Mr. GATES. As I commented a moment ago, sir——

Mr. LUJAN. Tying reprocessing and the AFR together?

Mr. GATES. The reprocessing, closing the fuel cycle, and the acquisition of the Barnwell facility are all matters that are still unresolved, but they are still being discussed within the administration. Hopefully, the Department would at some point in time be able to acquire that facility because, as I indicated, it would save us an awful lot of time by getting on with the business of reprocessing fuel.

Mr. LUJAN. Do you feel that the picture is a little brighter in the AFR and reprocessing areas?

Mr. GATES. I think it is much brighter, sir, than it was 2 months ago.

Mr. LUJAN. All right. One final area that I might want to discuss with you is in the gas-cooled reactor area. The HTGR, that's now in St. Vrain, Colo. One of the items of discussion that came up on this trip to Mexico was the HTGR—again I don't want to dwell too much on that because I'm not here selling you the HTGR—but the reason that the Mexicans wouldn't even consider something like that is because 300 megawatts is its range, and they want to see something like a 600-megawatt operation. I'm told that it's possible. It's probably gone beyond the stage of where it's just R. & D. It's possible to demonstrate the 600-megawatt plant at this time.

Perhaps the DOE could work with some of the agencies under DOE, the power marketing agencies, Bonneville, TVA, some of those, to put in stall a HTGR. I think that there could be a market for it across the country, a different type of technology.

Mr. GATES. We think it's a valuable technology, Mr. Lujan. I don't believe the Department is currently looking at the HTGR as a source of electrical energy; rather, we are more inclined to regard it as having other commercial applications in high process heat. We do hope, however, to continue with the technology development.

Mr. **LUJAN**. It was just a thought that I wanted to leave, that maybe the outfits like Bonneville and TVA and those power marketing agencies might be in a position to make this technology work instead of Government funded research. Maybe that's the way to do it.

One final thing. You mentioned the cleanup of Three Mile Island and the problem of what are we to do with the waste. What's the thought of DOE? What are you thinking about? Are you to a stage where you can say this is what we ought to do?

Mr. **GATES**. As you know, sir, there are a great number of entities involved in trying to resolve the still existing problems at Three Mile Island, and certainly the Federal Government is one of them. There are studies underway currently that are expected to be available, I think, within a month or so that will try to evaluate and direct the efforts of the several agencies involved.

Specifically to address your question; yes, I think the Department of Energy can play a role there insofar as a cleanup program is concerned with respect to acquiring the waste that exists now, mostly in the form of the reactor core and the water that's in the plant. I don't think decisions have been made yet.

Mr. **LUJAN**. And do what with it?

Mr. **GATES**. They want to solidify the waste, and considerably reduce the volume, reduce it to a solid, and then dispose of that waste. Now, I don't think a decision has been made, sir. I presume that that disposal will take place on a Federal reservation of some kind.

Mr. **LUJAN**. Are you talking about solidifying it there?

Mr. **GATES**. Yes, sir.

May I ask Mr. Meyers to respond more definitively?

Mr. **LUJAN**. Yes.

Mr. **MEYERS**. We have a research and development program under way now, and one of the programs is to solidify the resins that have already been accumulated, based upon the cleanup that has been done. We would not solidify it at the site, but probably move it in the form of liners to one of the DOE facilities. The idea would be to demonstrate a solidification of abnormal nuclear wastes generated as a result of the TMI accident. In this case we have a kind of waste that was never anticipated. The objective of the research and development program is to address how to treat it.

Mr. **LUJAN**. What about West Valley?

I'm sorry to be taking too much time, Madam Chairman, but I just wanted to follow up on this.

If I remember correctly, we were going to put some kind of a facility in there, weren't we, to solidify?

Mr. **MEYERS**. Yes.

Mr. **LUJAN**. It seemed like a portable thing when we were talking about it. Maybe that's not what it is.

Mr. **MEYERS**. Unfortunately, it's not portable.

Mr. **LUJAN**. It's not portable.

Mr. **MEYERS**. The West Valley demonstration project, as you know, was passed into law last year. It required the Department to solidify some 600,000 gallons of high-level liquid waste, a waste similar to the kinds that are stored at some of our defense facilities. We know how to manage those. The waste at Three Mile Island is not quite high-level waste, but it's not low-level waste, either. It's somewhere in between, and in addition, it is adhered onto resin material. The General Public Utilities has pumped water through the demineralizers so that the water can be reduced and concentrated in resin form. The next step is to take the contaminated resins and solidify them so that they can be disposed of. So it's a much different kind of waste than the West Valley waste.

Mr. LUJAN. It sounds very complicated, but at least you have it in hand.

Mr. MEYERS. The important point is that we do have a program underway now. Now, whether or not we can get some new initiatives underway with the new administration remains to be seen.

Mr. LUJAN. Thank you very much.

Thank you, Madam Chairman.

Mrs. BOUQUARD. Now, Mr. Gates, to get back to your testimony, on page 6, I would like to go back to the subject of positive public information, which I think is very important.

I think that our area of communications has, to put it mildly, been severely lacking in accurate information about our nuclear energy program, and I think not only the Department should take the lead in positive information dissemination to the public; I think that we should also take a very good observation of what's happened in the previous administration in reference to the nuclear handbooks that were available, the glossaries, and the general concepts, basic concepts, of the nuclear industry, as well nuclear waste.

Do you anticipate setting aside funds within your office for public information programs? Do you really see these programs actively and accurately expressing to the American people the confidence that we must have, and that we should have, in safely disposing of that radioactive waste?

Mr. GATES. I agree with the thrust of what you say, and the Department agrees. It's of fundamental importance to present the facts to the American public, and if the facts are presented I think a rational person can reach only one conclusion: that is, that this is the way to go.

I think the Assistant Secretary for Congressional, Interdepartmental and Public Affairs, a newly established Office as of today, will have funds available to put out the necessary pamphlets, brochures, press releases, or whatever is required in setting forth the facts about nuclear energy.

Mrs. BOUQUARD. I will stand corrected if I am wrong, but it's my understanding that this information was destroyed by the previous administration with reference to our nuclear program.

Mr. GATES. I have read the report, which I think you might be referring, wherein the Department was criticized for, really, a failure to come forward with the necessary information on nuclear energy, and I agree with that report. I read also in the report about the destruction of documents. I have no personal knowledge of that situation.

Mrs. **Bouquard.** Mr. Meyers, would you care to comment on this?

Mr. **Meyers.** Yes. I just handed General Gates a note.

We have in place in our waste isolation program in Columbus, Ohio, a rather extensive program of public information, where we have prepared documents that in my mind explain the program and the problems in plain English so that the average citizen can both read and understand it. We are working on how to disseminate that now at our initiative. Right now it operates on "You write in, and we'll send you whatever you want to know." We're trying now to look at ways to expand that so that we can get information to various places, as I said, on our own initiative. But that program is in place now for the waste program.

Mrs. **Bouquard.** Very good.

In another area, does the Department see any linkage between its R.D. & D. programs for civilian nuclear power and any programs directed at the production of defense materials? If so, do you think this can be done without jeopardizing our commercial availability?

Mr. **Gates.** There's an element of the question that I don't think I understand. Does the question, ma'am, refer to competition?

Mrs. **Bouquard.** The linkage between our civilian programs and the production of defense materials, for instance, plutonium, beryllium, LMFBR, HTGR, advanced isotope separation, these types of things.

Mr. **Gates.** May I address the advanced isotope separation problem?

Mrs. **Bouquard.** Please do.

Mr. **Gates.** As I think you know, there are several schemes or methods by which the isotopes may be separated other than the centrifuge or the presently used gaseous diffusion. These are being examined. They look encouraging from the point of view of cost-effectiveness, if you will. We are probably not far enough down the pike yet to make an accurate determination of the cost of the SWU produced by the AIS system, or as produced by gas centrifuge or gaseous diffusion. I think it will be 8 or 9 years before we can really evaluate all the parameters that need to be evaluated in making that cost-effectiveness determination. In the meantime, of course, we are proceeding with the gas centrifuge program.

With respect to the linkage between the civilian and the defense reactor programs, there are a few considerations here that I think I need to address.

One is that defense reactors as they occur today at Savannah River or at Hanford, Wash., are unlicensed facilities. We think that's appropriate. We do not believe that elements that play such a fundamental part in the national security program of the United States have a necessity to be licensed, or regulated, if you will. On the other hand, of course, the commercial reactors are a product that require licensing, and we understand that very clearly. The relationship, the linkage, if you will, technology-wise is a continuing linkage.

Now, if I'm missing the thrust of your question I'm sorry. I'll try again if I've missed the thrust of your question.

Mrs. **Bouquard**. Do you think it jeopardizes the commercial viability of this technology by linking it to the defense programs, R. & D. programs?

Mr. **Gates**. No, ma'am. As a matter of fact, I believe that, if we'll all recall historically, the development of the reactor was a function of the defense needs back in the early days of World War II, and that spurred the development of an industry that today is translated into the commercial environment. I think the linkage has been vital and important to both sides of the fence.

Mrs. **Bouquard**. Thank you.

Do you consider the Clinch River breeder reactor primarily a test facility instead of a demonstration plant?

Mr. **Gates**. I think the answer to that is yes. I spoke to that a few moments ago. The CRBR is a step up in power rating from where we were on the experimental breeder reactor to where we want to go in a commercial reactor. It is not prototypic of a commercial reactor. It will have considerable value in R. & D. and testing. The answer to your question is yes, ma'am.

Mrs. **Bouquard**. Thank you.

Mr. Lujan.

Mr. **Lujan**. Thank you.

I just want to take 1 minute because I need to make a correction. It's been pointed out to me that I said that we had the Taiwanese dismantle a plant. It was not a plant. It was a program that they were looking for because under the nonproliferation agreements anybody that goes into, is looking into, making plutonium, and what they were trying to do, they have a lot of thorium and they were looking into a university laboratory experiment, being able to produce some uranium because they have a lot of thorium, as maybe a mix for a fuel.

I just wanted to make that correction, that it was not a reprocessing plant that they dismantled. It was a program that they were looking into.

Thank you, Madam Chairman.

Mrs. **Bouquard**. Thank you.

We're happy to recognize Hon. Harold Volkmer, a very important member of our committee. We're very happy to have you with us this year, Harold, on this subcommittee.

Mr. **Volkmer**. Thank you.

Mrs. **Bouquard**. The time is yours now for any questions that you might ask our panel.

Mr. **Volkmer**. Yes.

I'm sorry I was late because I was at another hearing next door, down the hall a little bit.

Briefly reading through your statement, one thing that concerns me that I have seen, I have seen repeatedly, the Mobil Oil advertisement that if we go to nuclear energy, we reduce our dependency on foreign oil, and I read that in your statement, and it appears to mean that if we go all nuclear, we don't have to import any more oil. But, that's not true. We know that. That's not true.

Mr. **Gates**. I don't think it will reduce the necessity for imports to zero, but, hopefully, it will take a big bite out of it.

Mr. **Volkmer**. All right. Let's look at it and see how big a bite it would take.

How much oil is used today for generation of electricity?

Mr. GATES. I'm not sure I know the answer to the question, sir. I think the United States is using somewhere in the neighborhood of 18 or 19 million barrels of oil per day, and I believe that.

Mr. VOLKMER. We're down to 17 now.

Mr. GATES. All right. And I believe that something like a third of that perhaps is used for electrical generation.

Mr. VOLKMER. Would you believe that only 10 percent of our total oil use is used for electrical generation, sir? And if it's only 10 percent, that's all we can replace with nuclear power.

I agree with you we should do it. I'm not arguing that. But I don't believe we should lead the American public to believe that if we have nuclear powerplants throughout this country we no longer have to import oil. That's misleading. If you find different figures I would appreciate your providing them to me.

Mr. GATES. I can't attack your figures, sir, nor do I intend to. It's my impression that about a third of the U.S. daily consumption of oil is used for the generation of electricity.

Mr. VOLKMER. That is your impression?

Mr. GATES. But you have given me a figure of 10 percent, and I don't know to what extent idle capacity in the United States might make up for the difference between your figure and my figure.

Mrs. BOUQUARD. Would the gentleman yield?

Mr. VOLKMER. Yes.

Mrs. BOUQUARD. According to my figures, we're using 1½ million barrels of oil a day to generate electricity and an equivalent amount of gas, and this represents about half of what we are importing.

Mr. VOLKMER. Yes. That includes the gas.

Mrs. BOUQUARD. Yes, sir.

Mr. VOLKMER. I don't want to include the gas because we're not importing that for generating electricity. I want to include the oil, and I want to replace the oil, and what I think we ought to do is try to site nuclear powerplants. I have no objection to them. I have one coming in in my district in Missouri, the only one that's going to be in Missouri. We don't have it yet. It's going on line, we had hoped, by next year, but now it looks like 1984.

I have no objections. I want you to know that. But I think we ought to look strongly at trying to site them where we do have them. We have electricity all over, and that's inefficient use of electricity. I think we should try to site them where we do have oil burners if we can, if it can be done, and we ought to replace that oil that's generating electricity—I agree with that—either with nuclear or coal, OK?

Mr. GATES. Yes, sir.

Mr. VOLKMER. You understand?

Mr. GATES. Yes, sir, I do understand.

Mr. VOLKMER. But I think we ought to be quite honest with each other and realize what we're doing. If we can replace 1½ million barrels of oil a day I'm all for it. But that's only 1½. That's not 6 or 8. It's only 1½.

Mr. GATES. I understand, sir.

Mr. VOLKMER. My next question is a serious one. I think we all have to look at this because I think we in Congress are going to be looking at it later on. Those in the nuclear industry for power generation are going to have to look at it in the long run.

We have TMI. A billion dollars, I don't know how much, cost of cleanup. Who's going to pay for it? I understand that they may be coming down here to ask the Congress to appropriate money to pay for it. Personally, I'm against it. The nuclear industry is going to have to look at that.

Waste disposal. Who should be responsible for waste disposal? The utilities should be responsible for waste disposal. That's a cost of doing business. We don't dispose of residue from coal for those that use coal. We don't build the scrubbers to clean up what comes out of the stacks.

Maybe you're going to be able to work it out, but I do think that they should be responsible for it. How do you feel about that?

Mr. GATES. I wanted to address an earlier comment you made relative to the cost of the fuel and the cost of the waste vis-a-vis the other costs.

I believe that there have been a great number of studies made, sir, that indicate that all costs considered of a nuclear versus another energy source, such as coal or oil, the nuclear always comes out ahead.

Mr. VOLKMER. I don't argue that. I'm not arguing that. I'm just saying who should bear the brunt of the expense of it. Should that be a business expense or should that be an expense to the public?

Mr. GATES. I think it's a business expense, sir.

Mr. VOLKMER. And I think cleaning up TMI is a business expense. Now, if all the utilities and everybody, the private and the public, want to get together and create a fund among themselves to do that if it happens somewhere, that's fine. But that should be a business expense. That's part of generating electricity. That's a hazard in it.

Mr. GATES. We spoke a while ago, sir, of the fact that there is a study currently commissioned by Secretary Edwards to examine the Three Mile Island situation as a matter of priority and to see if we can't establish reasonable roles for all the participants to get on with the cleanup of the program.

Mr. VOLKMER. What about waste disposal? Who should bear the expense of that, the public, or is that a business expense?

Mr. GATES. I think providing the technology for the waste cleanup is probably a Federal responsibility.

Mr. VOLKMER. I don't argue that. I agree with that. But as far as the actual doing of it?

Mr. GATES. I think that's a utility responsibility.

Mr. VOLKMER. Thank you.

Barnwell, if we go to recycling, and I think the present Secretary would like to open it up again, that should also be a private matter, should it not?

Mr. GATES. We feel at the present time, considering the state-of-the-art, that the initial reprocessing of fuel in the United States should be a Federal responsibility.

Mr. VOLKMER. Will you explain your reasoning?

Mr. GATES. I think it's an area of risk, which utilities would probably not be prepared to take in the present climate. I think if we can demonstrate satisfactory operation of a large reprocessing facility we will instill in industry a confidence that we can go forward with industrial participation, commercial participation.

Mr. **Volkmer**. You're talking about a demonstration plant with known technology, is that correct?

Mr. **Gates**. Yes, I think that's correct, sir.

Mr. **Volkmer**. Thank you. The reason I asked that—and I don't disagree with you, if you want to know the truth, but if I follow the Secretary's logic, as I was over in that meeting over there, the Government should not pay for a demonstration plant that uses known technology. That's fossil fuel plants. That's coal gasification plants. That's coal liquefaction plants. He eliminated those. But now I hear from the Secretary, that the Government should pay for nuclear demonstration plants.

Now, why the difference, I would like to know.

Mr. **Gates**. I think the difference is the risk factor and whether or not we think the utility is willing to venture capital in a high risk area.

Mr. **Volkmer**. It's the same thing over there. It's the very same thing. You're not going to see private business taking a risk of spending billions of dollars on some technology, SRC-2, SRC-1, direct liquefaction. You're not going to see them do it.

Mr. **Gates**. I'm not decrying the importance of synthetic fuels. Don't misunderstand me. Both of us are involved in the environmental problems. But we are involved also in the regulatory licensing function, which is not a paramount consideration to them. It is because of those regulatory delays, the high cost of construction capital, the high inflation rates over the past several years and projected into the future.

Mr. **Volkmer**. Now you're talking about generating plants. I want to stick to Barnwell right now.

Mr. **Gates**. All right, sir.

Mr. **Volkmer**. I want to be able to try to somehow get through my mind what distinguishes going on with a nuclear demonstration project subsidized by the Federal Government, when it's wrong to go ahead with a demonstration project of technologies in other areas. I'm hardheaded. Sometimes I'm a little dense. Some people call me dumb. But I just can't see it. I need someone to tell me the difference.

Mr. **Gates**. May I ask Dr. Dillon to respond?

Dr. **Dillon**. Mr. Volkmer, I think one of the key differences is that we're not thinking of reprocessing as principally for the benefit of the existing light water reactors. It's the key to the future of nuclear power. It's the front end of the whole breeder system, and so it's not really demonstration of a commercial plant that we are developing options for as much as demonstrating a closed nuclear fuel cycle. It's a developmental activity, and I think that's what distinguishes it from some of these other technologies, simply because it has to be viewed in the larger context of our overall breeder program and its central role for that breeder program.

Mr. **Volkmer**. All right. What's the difference between that and the other processes? I don't care if you call them solvent recovery of coal 1 and 2 or direct liquefaction of coal. What's the difference, when they could also lead to technological developments that would not otherwise come about?

I do understand what you're saying. You're saying that if the Government doesn't do this, the technology will not develop in this country.

Mr. DILLON. I can't talk directly to those projects. But it was my understanding that those projects are designed to demonstrate prototypical technology for commercial application.

What I am saying is that the options that are being considered by the Administration for Barnwell are options that would be of a developmental nature for the general nuclear fuel cycle that's appropriate not only to light water reactors but, more importantly, for ultimate application to breeder reactors.

Mr. VOLKMER. Thank you very much, Madam Chairman.

Mrs. BOUQUARD. Thank you, Mr. Volkmer. We're happy to have you as a member of our committee.

Mr. Gates, Dr. Dillon, and Mr. Meyers, we appreciate your being here as our first witnesses in 1981. It's a good kick-off.

Thank you very much.

Mr. GATES. Thank you, ma'am.

Mrs. BOUQUARD. We would like now to welcome Dr. Douglas Pewitt, Acting Director, Office of Energy Research, the office that has oversight of our magnetic fusion program. We're also happy to see Dr. Kintner the Director of the Office of Fusion Energy at DOE with us today.

I think that as Dr. Pewitt has generally outlined in his written testimony what is coming down the pike in fusion, perhaps we may see some disappointments in the requests and we may have to sort out of these some options on the funding. But we do look forward to seeing whether or not the DOE has the same priorities as our committee when we get to the March 10 submission.

I'm going to turn our fusion hearings over to Congressman Young, who is a very valuable member of this committee.

One of the goals that I set out after becoming chairman of this subcommittee was to try to seek out the advice and assistance of those members, particularly who have participated most in our hearings. I think it would be less than wise if we did not use the talents of all our members and especially my distinguished colleague from Missouri. Therefore, at my request Congressman Young will preside over our fusion hearings today.

Congressman YOUNG.

Mr. YOUNG. Thank you, Madam Chairman.

I appreciate the opportunity to be able to participate. I think it is important, as Madam Chairman had indicated, to have the opportunity for everybody to become very much involved, particularly in the energy field, as all of us in this country are so vitally affected by its progress. Let us proceed.

We would like to have Dr. Pewitt now give his testimony.

[The biographical sketch of Dr. Pewitt follows:]

U.S. Department of Energy

# BIOGRAPHY

## N. DOUGLAS PEWITT

Dr. Nelson Douglas Pewitt is Deputy Director of the Office of Energy Research in the Department of Energy. In this position, he assists the Director in the overall planning, leadership and management of activities assigned to the Office of Energy Research. These activities include providing advice to the Secretary on the physical research and energy R&D programs of the Department, as well as advice on the multipurpose laboratories, certain education and training activities and budgetary priorities for the physical research and energy R&D programs of the Department. The Office of Energy Research also manages DOE's basic sciences, high energy and nuclear physics and magnetic fusion energy programs. Dr. Pewitt was appointed to this position on May 21, 1979.

Dr. Pewitt served as Acting Director from May to December 1979, and since January 21, 1981 to the present time, is again serving in the dual capacity of Deputy Director and Acting Director of Energy Research.

Prior to joining the Department of Energy, Dr. Pewitt served in the Office of Management and Budget with responsibilities for the review and analysis of the programs of the National Aeronautics and Space Administration, the National Science Foundation, and the Smithsonian Institution, as well as the nuclear energy, defense and energy research programs of the Department of Energy. Dr. Pewitt joined the Office of Management and Budget in 1976 as a Budget Examiner for Nuclear Power Programs. During the previous year, he had worked as a Senior Analyst in the Marine Corps Operations Analysis Group at the Center for Naval Analyses.

Dr. Pewitt received a B.A. from the University of West Florida in 1969 and a M.A. and Ph.D., in elementary particle physics, from Florida State University in 1971 and 1974, respectively.

From 1961 to 1969, Dr. Pewitt served in the U.S. Navy as a Naval Aviator and accumulated over 5000 hours of pilot time.

In September 1980, Dr. Pewitt received the Presidential Meritorious Executive Rank Award and on January 19, 1981, was awarded the Department of Energy Outstanding Service Medal for superior performance as a career member of the Senior Executive Service.

Dr. Pewitt resides in Falls Church, Virginia, with his wife, the former Sue Woods, and their two children, Leslie Paige and Douglas Woods.

## STATEMENT OF N. DOUGLAS PEWITT, ACTING DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY, ACCOMPANIED BY EDWIN KINTNER, ASSOCIATE DIRECTOR FOR FUSION ENERGY, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY

Dr. PEWITT. Thank you, Mr. Chairman and members of the committee.

It is an honor to appear before you today to discuss the major issues affecting the Department's magnetic fusion energy program. As you know, I cannot go into the budget specifics at this time. Rather, I will be presenting on behalf of the Department its underlying philosophy.

The Department's overall objective for fusion is to develop its highest potential in an environmentally and economically acceptable way. Fusion is one of the major energy options that may provide access to an inexhaustible energy resource base that could serve the Nation, and the world, for centuries to come.

Developing this option to its highest potential and determining whether its benefits can be made available to future generations is a challenging and difficult task. While much of the knowledge needed to develop fusion energy already exists and rapid progress is being made in scientific understanding, substantial research is still needed on the configurations and conditions that will be required for practical fusion reactors. Moreoever, there are many complex engineering problems that will have to be addressed to make fusion a reality. Although expectations are high that these problems can be surmounted, the effort will take time and will be expensive. In view of this background, the Department has designed a program for fiscal year 1982 that is sound and responsible and that is intended to assure vigorous progress, while being fiscally and managerially responsible.

As you know, the basic scientific problem in magnetic fusion is to heat and confine a hot plasma of nuclei and electrons for enough time at a high enough density for nuclear fusion reactions to take place often enough to result in net energy production. To obtain these conditions, the hot plasma must be confined by intense magnetic fields that are shaped to trap the plasma and keep it from escaping. Several difficult and somewhat conflicting conditions must be met simultaneously. Two generic types of magnetic traps have been devised that have a high potential for meeting these conditions. These are the tokamak, or the closed, donut-shaped configuration, and the magnetic mirror, a geometery with the ends plugged by a complicated magnetic field. Work on these systems is the backbone of the program.

Recent years have seen a progression of experiments that have revealed more and more about how the plasma behaves and how it can be heated, how fresh fuel can be injected, how impurities can be extracted and how instabilities can be avoided or suppressed. During the past year, technical progress in fusion research on tokamak, or toroidal, and on mirror systems has continued around the world. These advancements are noted in the statement for the record, which I will skip over in the interest of time.

Looking to the future, the major scientific milestone will be the successful operation of the tokamak fusion test reactor under conditions of scientific breakeven, that is, more energy produced by the plasma than is consumed in heating it. There is high confidence that this will be achieved by the middle of the decade or perhaps earlier. A major scale up of the mirror concept, the mirror fusion test facility-B, is expected to be ready for plasma experiments in fiscal year 1985. The mainline experimental effort in magnetic fusion will continue to be supported by projects using smaller devices and by a wide ranging program of applied plasma physics research.

The rapid progress of magnetic fusion research during the last few years led the Director of Energy Research to request in 1980 that the Energy Research Advisory Board undertake a comprehensive review and evaluation of the program. That review has been completed and its results have been factored into the planning of the program. The ERAB review came to two major conclusions: first, that the program is making very good scientific progress and, second, that the program is ready to initiate a parallel program of fusion engineering development. These basic conclusions are in agreement with those of two other external groups and have led to a shift in the overall conceptual design of the program.

The engineering development effort envisioned by ERAB would be centered around a major new experimental facility, the fusion engineering device. This facility would be of a scale and scope sufficient to address major engineering design issues that must be faced if fusion is to become a practical reality. A center for fusion engineering was recommended to be established to pull together the various efforts related to engineering development and to provide an overall management focus.

However, the Department is not proposing to embark on a commitment to the fusion engineering device or the center for fusion engineering at this time. The fiscal year 1982 program that will be proposed will undertake exploratory study and initial design activities intended to enable us to build and operate a successful fusion engineering device at some later time, if appropriate. Engineering development of the scope required is very costly. The ERAB study suggests that such a step would involve doubling, in constant dollars, the real expenditure level of the program over the next 5 years, and that the fusion engineering device would cost about $1 billion. Faced with the need for fiscal constraint, we are not proposing to take steps that would imply such large future year expenditures. However, the program proposed will represent a significant expansion of the program effort. It will allow the Department to sharpen the center for fusion engineering and fusion engineering device concepts and provide an improved basis for future decisions, while continuing the strong, and highly successful, scientific fusion program.

Although the Department strongly supports the development of magnetic fusion, the administration's commitment to making nuclear fission a fully viable source for the Nation's electrical energy supplies makes an acceleration of fusion development less urgent. The cost implications of fusion engineering development are still unclear and the feasibility and appropriate characteristics of the fusion engineering device are too uncertain for such a step to be prudent now. The Department cannot embark upon a program that is predicated on an unbroken series of technical successes; we must plan prudently and incorporate into our planning the possibility for scientific or technical disappointments. Before the Nation undertakes such an expensive effort, it is essential that thorough analysis and assessments be undertaken. The Department plans to review this situation with great care in the formulation of the fiscal year 1983 budget.

Essential elements of the programs will be continued in the ongoing fusion program. We will continue efforts to improve the program's theoretical underpinning, explore alternative fusion concepts, and improve the engineering and technology base. We will also continue to pursue the mainline tokamak and mirror concepts. Details of these efforts are provided in my backup statement, which I will skip over for the sake of time.

Pursuing a vigorous program in times of fiscal austerity inevitably involves some difficult choices. The 1982 program, as proposed, will be restructured to eliminate high future year costs for certain planned projects that are not essential and to eliminate ineffective efforts.

Each of the projects to be cancelled has been well planned and justified scientifically and would have produced useful technical input for the fusion engineering device and subsequent developments. Lack of this information will increase somewhat the degree of technical risk in the overall program. However, none of these projects is absolutely essential to fusion development. Their elimination, while unfortunate, is preferable to threatening the success of the major elements of the program.

Finally, to return to the broader issues of the overall strategy for the development of magnetic fusion, it is clear that great benefits can accrue to the Nation and to the world from learning how to tap this virtually inexhaustible energy source. The issue is not whether to proceed, but how to proceed at what pace, with what timing, with what degree of technological risk, and what expenditure of resources. Although it is not a perfect analogy, we should recall that it took almost 20 years to move from the first fission proof of principle demonstration by Enrico Fermi to the first commercial scale reactor, Yankee Rowe. That lengthy time scale was necessary even though there were fewer nontechnical constraints on development programs in those days. There was a parallel military effort both for nuclear materials production and ship propulsion, and the technological obstacles to be overcome were simpler. In addition, any radical new central station electrical generation technology will severely stress the financial resources and the institutional capabilities of the private sector, especially the electric utilities. This is not necessarily a bleak picture; rather, it is a realistic one.

In a sense, fusion represents the epitome of the type of research and development activity that requires Federal support. It is too long-range for significant private investment; the chances of success are uncertain; the investment required is large; society as a whole will benefit; and the potential benefits are very large. For all these reasons, this Nation deserves a program that fully addresses the central purpose, to develop fusion and determine its highest potential.

In summary, the program and strategy for magnetic fusion energy that the administration will propose are prudent and sound and represent an investment that will provide good value to the American people.

This concludes my prepared testimony, and I would be prepared to respond to your questions, sir.

[The prepared statement of Dr. Pewitt follows:]

Statement of N. Douglas Pewitt
Acting Director
Office of Energy Research
Department of Energy
Before the
Energy Research and Production Subcommittee
of the House Committee on Science and Technology

February 25, 1981

Madam Chairman and Members of the Subcommittee:

It is an honor to appear before you today to discuss major issues affecting the Department's Magnetic Fusion Energy program. As you know, I cannot go into budget specifics at this time. Rather, I will be presenting on behalf of the Department its underlying philosophy,

The Department's overall objective for fusion is to develop its highest potential in an environmentally and economically acceptable way. Fusion is one of the major options that may provide access to an inexhaustible energy resource base that could serve this nation, and the world, for centuries to come.

Developing this option to its highest potential and determining whether its benefits can be made available to future generations is a challenging and difficult task. While much of the knowledge needed to develop fusion energy already exists and rapid progress is being made in scientific understanding, substantial research is still needed on the configurations and conditions that will be required for practical fusion reactors. Moreover, there are many complex engineering problems that will have to be addressed to make fusion a reality. Although expectations are high that these problems can be surmounted, the effort will take time and will be expensive. In view of this background, the Department has designed a program for Fiscal Year 1982 that is sound and responsible and that is intended to assure vigorous progress while being fiscally and managerially responsible.

As you know, the basic scientific problem in magnetic fusion is to heat and confine a hot plasma of nuclei and electrons for enough time and at a high enough density for nuclear fusion reactions to take place often enough to result in net production of energy. To obtain these conditions, the hot plasma must be confined by intense magnetic fields that are shaped to trap the plasma and keep it from escaping. Several difficult and sometimes conflicting conditions must be met simultaneously. Two generic types of magnetic traps have been devised that have a high potential for meeting those conditions. These are the tokamak, or closed, donut-shaped configuration, and the magnetic mirror, a geometry with the ends plugged by a complicated magnetic field. Work on these systems is the backbone of the program.

Recent years have seen a progression of experiments that have revealed more and more about how the plasma behaves, how it can be heated, how fresh fuel can be injected, how impurities can be extracted and how instabilities can be avoided or suppressed. During the past year, technical progess in fusion research on tokamak, or toroidal, and on mirror systems has continued around the world. In toroidal systems, there have been improvements in "Beta"--the measure of magnetic field efficiency in confining plasmas--here, in Japan, and in the Soviet Union. In fact, the previously assumed theoretical limit to this important value is now in doubt and is the subject of intense experimental and theoretical activity. At Princeton, scientists were able to raise the plasma temperature above the minimum required for igniting a plasma and almost to the value needed for a power reactor. In Doublet-III at General Atomic, and in T-10 in Moscow, tokamaks were operated with stable plasmas at values of their magnetic safety factor well beyond those required for power reactors.

Significant advances have been made in plasma heating, especially with radio frequency power, which has many potential advantages over previous plasma heating methods. These advances were made in the United States, in France, and in the U.S.S.R. Further, scientists were able to investigate a number of questions associated with maintaining plasma purity which imply simpler methods than were proposed previously.

Important new data were developed in machines called ASDEX and Wendelstein VII at Garching, in the Federal Republic of Germany, and DITE at Culham in England. These data indicate that the long sought objective of making tokamaks steady state rather than pulsed is now in sight. Finally, in the toroidal systems the Soviets operated a superconducting tokamak--T-7--with success.

In mirror systems, research was completed on the Tandem Mirror Experiment (TMX) at the Lawrence Livermore National Laboratory. It was research on the TMX which previously proved the tandem mirror concept of "plugging" the ends. TMX was shut down for modification and upgrade to test improved methods of end plugging which, if successful, could make mirrors a direct competitor of tokamaks as power reactor devices. On the basis of TMX success, the Mirror Fusion Test Facility is being modified for a full-scale test of the mirror principles.

The Elmo Bumpy Torus upgrade (EBT-S) at Oak Ridge National Laboratory continued to improve its performance with significantly increased heating power and frequency. A similar device in Japan--the Nagoya BT--demonstrated successful radio frequency heating by ion cyclotron techniques.

Progress continued in the technology programs as well. Neutral beam sources at 120 Kv energy and powers of 2 MW have been operated for more than one-half second; the length of these pulses is being steadily increased. In addition, high power, high frequency microwave tubes for heating plasmas in tokamaks, mirrors and EBT's have been operated at 28 Ghz and 200 KW steady state power levels and further development at 60 Ghz is beginning.

Perhaps the most hopeful aspect of the Development and Technology programs was the completion of the so-called STARFIRE studies by Argonne National Laboratory, McDonnell-Douglas, and Ralph M. Parsons Corporation. This study was the most mature and detailed projection yet made of what a fusion power reactor would look like. Based on what is known today, and what can be reasonably projected from present knowledge, its conclusions, although obviously far from definitive, are that a fusion electric generating plant may be competitive with either coal or fission plants.

Looking to the future, the major scientific milestone will be the successful operation of the Tokamak Fusion Test Reactor (TFTR) under conditions of scientific breakeven, that is, more energy produced by the plasma than is consumed in heating it. There is high confidence that this will be achieved by the middle of the decade or perhaps earlier. A major scale-up of the mirror concept, the Mirror Fusion Test Facility-B, is expected to be ready for plasma experiments in FY 1985. The mainline experimental effort in magnetic fusion will continue to be supported by projects using smaller devices and by a wide ranging program of applied plasma physics research.

This rapid progress of magnetic fusion research during the last few years led Dr. Edward Frieman, then Director of Energy Research, to request in 1980 that the Energy Research Advisory Board (ERAB) undertake a comprehensive review and evaluation of the program. That review, chaired by Dr. Solomon Buchsbaum of the Bell Telephone Laboratories, has been completed and its results have been factored into the planning of the program. The ERAB review came to two major conclusions; first, that the program is making very good scientific progress and, second, that the program is ready to initiate a parallel program of fusion engineering development. These basic conclusions are in agreement with those of two other external groups and have led to a shift in the overall conceptual design of the program.

The engineering development effort envisioned by ERAB would be centered around a major new experimental facility, the Fusion Engineering Device (FED). This facility would be of a scale and scope sufficient to address major engineering design issues that must be faced if fusion is to become a practical reality. A Center for Fusion Engineering (CFE) was recommended to be established to pull together the various efforts related to engineering development and to provide an overall management focus.

However, the Department is not proposing to embark on a commitment to the FED or the CFE at this time. The FY 1982 program proposes to undertake exploratory study and initial design activities intended to enable us to build and operate a successful FED at some later time, if appropriate. Engineering development of the scope required is very costly. The ERAB study suggests that such a step would involve doubling, in constant dollars, the real expenditure level of the program over the next five years, and that the FED would cost about $1 billion. Faced with the need for fiscal constraint, we are not proposing to take the steps that would imply such large future year expenditures. However, the program proposed will represent a significant expansion of the program effort. It will allow the Department to sharpen the CFE and FED concepts and provide an improved basis for future decisions while continuing the strong, and highly successful, scientific fusion program.

Although the Department strongly supports the development of magnetic fusion, the cost implications of fusion engineering development are still unclear and the feasibility and appropriate characteristics of the FED are too uncertain for such a step to be prudent now. The Department cannot embark upon a program that is predicated on an unbroken series of technical successes; we must plan prudently and incorporate into our planning the possibility for scientific or technical disappointments or setbacks. Before the nation undertakes such an expensive effort, it is essential that thorough analysis and assessment be undertaken. The Department plans to review this situation with great care in the formulation of the FY 1983 budget.

The ongoing fusion program contains several components. The Applied Plasma Physics activity is designed to provide an overall theoretical underpinning for the mainline efforts to operate the National MFE Computer Center, to explore alternative fusion concepts and to continue operation of the Fusion Plasma Research Facility at the University of Texas. The Development and Technology activity provides the engineering and technological bases for designing, constructing and operating fusion experiments and facilities. In particular, continued development of the Large Coil Test Facility at Oak Ridge National Laboratory and operation of the High Field Test Facility at Lawrence Livermore National Laboratory will be accompanied by work on neutral beam and radio frequency heating systems, vacuum systems and plasma fueling systems, along with continued efforts on tritium handling and fusion reactor materials problems.

Under the Confinement Systems activity the mainline tokamak and mirror concepts will continue to be pursued. The activities planned in this area for FY 1982 will continue major tokamak programs at MIT, Princeton and General Atomic as well as the magnetic mirror research at Livermore. Finally, under the Planning and Projects activity, construction of the two major experiments to determine the scaling of the leading fusion concepts to near-reactor size, TFTR and MFTF-B, will continue. It is important that these major projects remain on schedule; and additional resources will be proposed, where needed, to ensure that this happens.

Pursuing a vigorous program in times of fiscal austerity inevitably involves some difficult choices. The FY 1982 program, as proposed, will be restructured to eliminate high future year costs for certain planned projects that are not essential and to eliminate ineffective efforts.

Each of the projects to be cancelled has been well planned and justified scientifically and would have produced useful technical input for FED and subsequent developments. Lack of this information will increase somewhat the degree of technical risk in the overall program. However, none of these projects is absolutely essential to fusion development. Their elimination, while unfortunate, is preferable to threatening the success of the major elements of the program.

Finally, to return to the broader issues of the overall strategy for the development of magnetic fusion, it is clear that great benefits can accrue to the nation and to the world from learning how to tap this virtually inexhaustible energy source. The issue is not whether to proceed, but how to proceed--at what pace, with what timing, with what degree of technological risk, and what expenditure of resources. Although it is not a perfect analogy, we should recall that it took almost 20 years to move from the first fission proof of principle demonstration by Enrico Fermi to the first commercial scale reactor, Yankee Rowe. That lengthy time scale was necessary even though there were fewer non-technical constraints on development programs in those days. There also was a parallel military effort both for nuclear materials production and ship propulsion, and the technical obstacles to be overcome were simpler. In addition, any radical new central station electrical generation technology will severely stress the financial resources and the institutional capabilities of the private sector, especially the electric utilities. This is not necessarily a bleak picture; rather, it is a realistic one.

In a sense, fusion represents the epitome of the type of research and development activity that requires Federal support. It is too long-range for significant private investment; the chances of success are uncertain; the investment required is large; society as a whole will benefit; and the potential benefits are very large. For all these reasons, this nation deserves a program that fully addresses the central purpose, to develop fusion and determine its highest potential.

In summary, the program and strategy for Magnetic Fusion Energy that the Administration will propose are prudent and sound and represent an investment that will provide good value to the American people.

This concludes my prepared testimony, Madam Chairman. I would be pleased to respond to questions the Subcommittee may have.

Mr. YOUNG. Dr. Pewitt, thank you very much. We do have your prepared statement. Some of us have had a chance to evaluate a little bit of it.

The first question I would like to direct your attention to is on page 5 of your written testimony. I'm a little bit disturbed and puzzled by the emphasis on further analysis and evaluation. After testimony last year from DOE and our own fusion advisory panel we were led to believe that there was a consensus that we should move into the engineering phase. It just seems from your testimony on that there has been a complete change from what I was led to believe last year.

What are the major reasons that have caused the Department of Energy to apparently change its mind?

Dr. PEWITT. I think the point is that we are not going to be emphasizing engineering aspects, but that we will be addressing engineering issues to the extent that we can within the available resources. I have listed some of the details of that in the statement for the record. The question is whether one commits to a rather large expansion of the program before the current administration has time to review that commitment. We are not prepared to go forward with that commitment; at this time we intend to review it very carefully.

Mr. YOUNG. It sure flies in the face of the testimony that was presented to the committee last time, and I think we were all very, very excited about moving ahead, particularly into this field. I'm sure that the other members of the committee will have a chance to evaluate this testimony, and we're going to take a very, very critical look at the Department's position, from what I can see in the short time that I've had a chance to look at the testimony.

I would like to now go to the other members.

Madam Chairman, do you have any questions before you leave?

Mrs. BOUQUARD. Thank you very much, Mr. Chairman.

Is there any doubt in your mind, Dr. Pewitt, of the technical readiness of the magnetic fusion program to move into the engineering development?

Dr. PEWITT. That's not in question. We had a very distinguished panel last year, a blue ribbon panel, take a look at this, and they said that the program was prepared to move into engineering development, and, in fact, we are moving into areas of engineering development. It's a question of the timing and the need within the overall context of this administration's energy program and the need for additional central station power generation technologies.

Mrs. BOUQUARD. Really, to me the magnetic fusion program appears to fit within President Reagan's guidelines as Secretary Edwards expressed them yesterday with respect to long-range high risk research. It seems to me that OMB really wants more money in this area than does the Department, and I just want to know what factors influenced the Department's decision to not move ahead aggressively.

Dr. PEWITT. You are absolutely correct, of course. This is long-range, as I said. This is the prototypical type of program that the Federal Government has to be involved in, and it's not a question of whether we're involved. In terms of constant year dollar funding level, we are proposing a substantial increase in the program level.

There is no doubt about that. It's a question of how fast you proceed and when do you make a major commitment to doubling, in real purchasing power, this program over what period of time. It's not a question of whether. It's when, and how fast. The administration, the Department, wishes to look at this carefully, and we have different policy officials in the Department, and they wish to review it.

Mrs. **BOUQUARD**. Dr. Kintner, would you care to comment on the program?

Mr. **KINTNER**. I don't have anything further to add. It seems to me that Dr. Pewitt has put it very clearly. It's not a question of technical readiness, but a question of willingness to make the commitment to future year expenditures.

Mrs. **BOUQUARD**. Do you envision any stretch-out of the program based on the Center for Fusion Engineering?

Dr. **PEWITT**. Certainly there will be a stretch-out because we're not making a commitment this year. I don't know whether it's a 1-year stretch-out or what it is. It's subject to review, and it will be reviewed this summer.

Mrs. **BOUQUARD**. I was wondering if it would be in a time frame consistent with the Magnetic Fusion Engineering Act.

Dr. **PEWITT**. I think there is no intention at this time for the Department to embark on the schedule that was laid out in the Magnetic Fusion Engineering Act, no, ma'am.

Mrs. **BOUQUARD**. You do not think it is proper to comment on it?

Dr. **PEWITT**. No; I said there is no intention on the part of the Department to embark on that program at this time. We'll review it this summer. We certainly will not be proposing a real increase of 25 percent in the 1982 budget over 1981.

Mrs. **BOUQUARD**. Do you feel that by the summer you can provide us with some milestones and some sort of estimate or projection for the next 10 years on the construction of the fusion engineering device?

Dr. **PEWITT**. I am not sure when we will be able to do that. It will be a subject of intense review throughout the summer, and it may be in the fall before we have formulated that.

Mrs. **BOUQUARD**. Thank you very much.

Thank you, Mr. Chairman.

Mr. **YOUNG**. Mr. Goldwater.

Mr. **GOLDWATER**. There seems to be some contradiction over last year's testimony and thrust by the Department and the presentation that you made today. It seems that there comes a time with any research program when it becomes more cost-effective to move forward aggressively than it is to just maintain a constant funding level, with the intent of just having some kind of small improvement, say 10 percent per year.

Last year the Congress looked very hard at the cost/benefit/risk ratios for fusion development, and the conclusion, as I understand it, was that the program would cost the taxpayers over $2 billion, 1980 dollars over and above the cost projected by our fusion bill, if, in fact, we held to a constant figure. I might add that economic arguments which try to assess cost/benefit ratios if applied here are of little value because no one really knows what the economics will be in any advanced energy system until it's evolved through the engineering development phase. Congress felt the most cost effective method of finding this information, with an acceptable risk, was to move aggressively for a 1990 engineering demonstration project.

So I'm a little bit curious as to the fact, as your testimony suggests, that, for instance, the utilities would not be interested in fusion power. It implies that you know something that perhaps the Congress does not, and I'm wondering if you could discuss a little bit more any technical setbacks or negative assessments that have occurred since you testified last year which have caused the Department to refigure its need for an aggressive program.

Dr. **Pewitt**. You've asked four questions. I'll try to tick them off one at a time.

No. 1, are there any technical setbacks? None that I know of. We continue to make good progress.

With regard to whether or not we are continuing the program at a constant level of funding, we will be proposing a real increase in the program funding level in terms of purchasing power.

The comment about the utilities, do I have any special knowledge about the utilities, no. I just know that any new technology and the capital formation and the technological wherewithal that utilities, the private sector, have to have to commercialize that will tax the private sector that's involved in forming the capital, in building the plants and operating the plants. That's true for any new technology, and there's a question of what technologies are going to be in or what's competing in that time frame. No one in this room knows the answer to that question. It is something that we must factor into our planning.

With respect to the cost/benefit, that's really not at issue. We're faced with some fiscal realities. One does cost/benefit analyses and then one does affordability analyses when one is doing a Federal budget, and that's what's involved in this. If funding were not limited we would be doing a number of things we're not going to be doing. We are shaving back on this program this year, and we are going to reassess it and take a look at that affordability question through the summer.

Mr. **Goldwater**. So your basic reaction here is driven by budgetary constraints and not necessarily a change in attitude or intents or purposes?

Dr. **Pewitt**. I think we have to look at the overall energy program, and what we're doing in the Department, what our alternatives are, how many technological options we need to develop, and how much we can spend on developing those options for central station power generation. There's no question that this is something we have to do.

There is an administration commitment, not just a departmental commitment, but an administration commitment, to review this question in-depth this summer with respect to magnetic fusion. I am not in a position to make a commitment to the committee today on when that review will be completed.

Mr. **Goldwater**. This is a review of the entire fusion program?

Dr. **Pewitt**. It is a review of the questions that I have addressed, the question of affordability, the number of central station power options, et cetera, that the Department can afford to develop within the resources that are going to be available to it. I don't personally believe that 1982 is going to be an unusual year in that we're going to face considerable funding constraints on what the Federal Government can spend, and we have to factor that into our future outlook. We will be spending less than was planned by the previous administration on energy R. & D. development, and one has to rack those priorities up and see where things come out.

Mr. GOLDWATER. When is that review to be completed?

Dr. PEWITT. I'm not in a position to commit to you when that's going to be done because we haven't settled on that. We haven't really looked at how much has to be done.

Mr. GOLDWATER. But it's in process right now?

Dr. PEWITT. Lots of things are in process right now.

Mr. GOLDWATER. I mean this specific review.

Dr. PEWITT. It has not started. It has not been initiated as of right now. We are still trying to settle our March 10 proposal to the Congress.

Mr. GOLDWATER. If you cut back on the fusion, or at least the emphasis upon, say, the tokamak fusion facility and cut back on the mirror facility and, say, just concentrate on engineering activities, does that not allow other candidates to all of a sudden begin to emerge again and thus become perhaps attractive, or not?

Dr. PEWITT. Two things. No. 1, I know of no proposals or any thinking to cut back on our major mirror or tokamak projects or effort. We will continue to have a strong program of alternatives to the mirror and to the tokamak. It was always our plan to continue a strong program in alternatives to strengthen the scientific base with whatever configuration one does go into with a power plant program.

Mr. GOLDWATER. But do you not create an opportunity for other concepts to somehow come back into the picture? Over these years of work on fusion, by necessity, you've had to eliminate some programs or some approaches just because of the mere cost of them as we escalate up through different levels, as some of the work that was being done out at Los Alamos with their——

Dr. PEWITT. Syllac.

Mr. GOLDWATER. Syllac work.

Dr. PEWITT. There's always the question of resource constraints. You will never get a scientific review that says "Never. This thing will never go any place." But there has to be some balance when the preponderance of technical evidence tells you that you're probably not going to get any place with this particular approach, and we drop it. We have to. It would be irresponsible for us not to do that.

We continue to have a strong alternative program, and a number of alternative ideas are being reviewed all the time. Some of those may eventually prove to be configurations that one might want to scale up, but in all of them you learn something more about the physics of plasma confinement. Just because something is not on the mainline doesn't mean it doesn't produce very valuable information, and one doesn't expect all these things to go to large demonstration power reactors. There is no possibility of that happening. One must gather information and develop the best configuration possible to pursue to larger scale. As that process goes on, things arise, things drop out. That's the natural evolution of a technology program.

Mr. **Goldwater**. Thank you.

Mr. **Young**. Mr. Lowery.

Mr. **Lowery**. Thank you, Mr. Chairman.

Dr. Pewitt, it strikes me that fusion has got to be one of, if not "the" most promising technology down the road for energy self-sufficiency. There seem to be very few, if any, down sides to it.

Why not proceed full speed ahead?

Dr. **Pewitt**. It's a question of economic constraints, and the fact that there is a long, hard, expensive program of engineering development ahead. There is no guarantee that it will be both economically and environmentally attractive. There seems to be no objection to it now, but when it becomes a real potential possibility, the objectors will come out of the woodwork like they do for anything that represents power generation. Any time you release a lot of energy in a small area you're going to disturb the world around it, and there will be people who will object to it. Have no doubt about that.

Mr. **Lowery**. What are the best estimates now to bring fusion online in terms of the timetable as well as the costs?

Dr. **Pewitt**. You can get any estimate you want to, from people who will tell you they'll do it in 5 years to people who tell you you won't see it until the end of the 21st century.

I think in my testimony I said that one must keep in mind, and though I said it wasn't a perfect analogy, that in very different times with regard to nontechnological constraints on programs that one took almost 20 years to go from a first reactor pile that worked to the first commercial nuclear powerplant, I don't know how long it will take. I'm not that smart. I don't have a crystal ball.

Mr. **Lowery**. Any estimates as to costs?

Dr. **Pewitt**. There are all sorts of estimates, but those are the same things. One can gaze into any crystal ball and come out with a number. We provided estimates last year that were our best estimates. Those are still our best estimates. I think it was like $15 billion.

Mr. **Kintner**. $12 to $15 billion, total.

Dr. **Pewitt**. Over about a 20-year period in constant dollars. But if you asked either Mr. Kintner or myself to bet our mortgage that that was the right number I don't think either one of us would be willing to do it.

Mr. **Lowery**. How much did we spend on the Apollo program?

Dr. **Pewitt**. I don't know.

Mr. **Lowery**. About $25 billion, Congressman Goldwater suggests.

You mentioned that there are always budget constraints. I don't recall there being too many in that program. We set a goal as a nation, and we committed ourselves to it, and we achieved it, and it would strike me that the same thing could be done in the area of nuclear fusion if we indeed made a national commitment to that goal. I suspect that there probably will be some grumblers along the way that maybe would want to sink it, particularly as we get close to bringing it on-line. But there seems to be few problems with it that we envision now, in terms of waste and otherwise.

Let me ask a couple of specific questions.

How will your budget recommendations impact the projects that are going on at the General Atomics Co. in San Diego regarding their Doublet tokamak research?

Dr. PEWITT. I am not prepared to address any specific projects. Those are mainline tokamak efforts, and I know of no proposals to scale those back.

Mr. LOWERY. What about General Dynamics, the superconducting magnet that they're working on now in the EBT-P?

Dr. PEWITT. I simply am prohibited from talking to details below what have been released. You're talking about specific projects, and as an administration witness I am prohibited from answering specific project questions like that. I'm sorry.

Mr. LOWERY. Doctor, I appreciate that, and I assume that would likewise apply to a question that Congressman Morrison would have asked, and that is: What are DOE's plans for your facility at the Hartford Engineering Development Laboratory at Richmond, Wash?

Dr. PEWITT. I'm sorry. May I be very candid with you? Although it's obvious to you that I have some information, the 1982 program dollars are not finally fixed at this point in time. Things are still in a state of flux, and I don't know when that will be concluded. It's going to be after today is over, I guess, no matter how late I work on it.

Mr. LOWERY. You haven't finished and put your blue pencil away yet, then.

Thank you very much.

Dr. PEWITT. It's not my blue pencil.

Mr. LOWERY. David Stockman's blue pencil?

Dr. PEWITT. No comment on that.

Mr. YOUNG. Mr. Lujan.

Mr. LUJAN. You have to realize that we all have our sacred cows around here when we ask about all of the different programs. I was prepared to ask you about the FMIT, superconducting magnets, and those sorts of things.

When do we get a chance at you to find out about those things?

Dr. PEWITT. I wish it were today. I honestly do.

Mr. LUJAN. Are you talking about a week, a month, a few weeks?

Dr. PEWITT. March 10 are the instructions that I am under before we can discuss on the record any of the budget proposals below the fact sheets that Mr. Stockman has provided the public and the Congress. I just can't talk about them.

Mr. LUJAN. All right. Let me ask a general question, then.

OMB wants more money than you do for fusion. Are you ready to cave in to OMB?

Dr. PEWITT. Is that personal, or is that official?

Mr. LUJAN. No. I'm talking about the Department.

Let me preface it by saying at different meetings that we've had, as you remember, Ed, when the fusion panel was here we were given some figures last year that at $450 million we would have fusion by the year 2000—very optimistic, perhaps not realistic—but that if we put in $750 million a year that it would be 1990. I'm not sure that those were the exact dates. But the committee was looking at accelerating, increasing the budget substantially for fusion. I don't know that that's in the cards, from what we're looking at.

But what bothers me is that DOE is saying less money than OMB is, and I would like to encourage you.

Perhaps the question wasn't a fair one. But I would like to encourage you to look at it more in terms of what OMB is talking about because if they can include those higher figures in their budget and still be very committed to reducing the overall spending in Government that's not a bad deal for fusion, and if that's our hope for the future, why not take that horse and ride it.

Dr. PEWITT. I think, No. 1, the Department doesn't believe it's our one single hope for the future. I cannot speak about OMB's point of view. You have information. You can certainly say things that you are privy to.

Mr. LUJAN. That's in a magazine article in Energy Daily, "Fusion, OMB Wants a Raise, More Than DOE Wants." It's nothing I'm particularly privy to.

Dr. PEWITT. That's a news report. We read news reports all the time about things we can't talk about up here.

Mr. LUJAN. Are you saying this isn't true that they want to put in more money than you do?

Dr. PEWITT. No, I didn't say that, if you're talking to me as a departmental witness.

Mr. LUJAN. I think the point was made that if OMB wants to put in more money don't fight them.

Dr. PEWITT. OMB has its sets of priorities; the Secretary has his sets of priorities. He's the Secretary of Energy, and he is defining the program that we are proposing, and as long as I work for the Secretary I will defend the Secretary's position.

Mr. LUJAN. All right. Try to convince him.

Thank you.

Mr. YOUNG. Thank you, Mr. Lujan.

As a result of the March 10 date we're going to have DOE back after the new budget is out. There are however a few quesitons we ought to ask in the few minutes left. You may be very brief in answering them, but I think we ought to get them into the record.

I would like to ask Mr. Kintner: Fusion generates more than just the central station power. There are some other things that it will do, isn't that true, sir?

Dr. PEWITT. It doesn't do anything right now. There have been a lot of studies that show there are other potentials, but I'm not ready to get up here and tell you that that's going to be economic. There are lots of things you can do. I don't know whether it's going to be economic or not, however it looks like it might be.

The problem facing the program now is not those problems. We continue to look at those issues. But the problem facing the program now is establishing its scientific feasibility, which I don't think there is any doubt about, and establishing its engineering feasibility, and what the likely economics are, and those are the questions in front of the program. A different generation of people will face up to that particular question. We will study them, and there is potential there, there is no doubt about that.

Mr. YOUNG. Everything that we seem to be hearing indicates that other people are moving ahead with fusion. Shouldn't we be looking toward the future a little more? If we don't move ahead with the advancements which we feel are possible won't we find ourselves looking at everything being produced by other countries. This would be just like the problems we're having in the automobile industry. If DOE at this point slows down all the potential things that this country has we may continue to be in the technology cellar? Looking at this room right here at all the NASA photos, I don't think there was a guarantee made when we moved into the space program that everything was going to be right and was going to be absolutely moving right on target. They've had to readjust, even when they press the button a few seconds. We did move very fast in those days.

Dr. PEWITT. Let's put it this way: I don't intend to be up here as a spokesman of the administration and say that I think this country is going to be looking at the tailgate of somebody else in this program. I don't believe that the program we are going to propose on March 10 is going to put us in that position. If it did I wouldn't be up here.

Mr. YOUNG. Your testimony that I've seen here this morning doesn't seem very strong with regard to the country moving ahead in the fusion program. It seems to be more related to some other realities. I think I discern something about moving forward with fission rather than moving ahead with the fusion. You've even indicated that that the power companies in this country aren't interested in the fusion program. I think Mr. Goldwater brought that out. Is that true?

Dr. PEWITT. I didn't say that the power companies are not interested. They certainly are. What I said is that there are some realities about power companies adopting any new high technology. It will strain their resources and their capabilities.

Mr. YOUNG. Very good.

Does anybody else have any questions?

Mr. LUJAN. Only that I, like you, don't get a positive feeling of moving ahead with it.

I am interested by your statement that DOE doesn't pin its hope for the future on fusion even though I too am not saying that that's the only possible recourse. I feel a reducing of the fusion effort in DOE coming. Is that your general impression?

Dr. PEWITT. There are those in the Department with that view. There are those in the Department with another view. I have personally spent a lot of time with the Secretary. I have discussed this subject in detail. I think it is fair to say that this administration intends to look at the program. We are not committed to go ahead with the program that was signed in by the previous administration. We intend to look at it this summer, and that's an administration commitment. I don't know what the answer is going to be. I don't know when the review will be completed. It will be completed before we bring the 1983 budget up here for your consideration. There are diverse views. I think that Secretary Edwards is a very honest and open man, and we intend to review it, and I have no doubt about his personal commitment to do that.

Mr. LUJAN. Are you saying that within DOE there are those who are going to Secretary Edwards and saying, "We have to reduce the fusion effort," and there are those who are going to him and saying, "We must increase the fusion effort," and then a third category that says, "It's fine like it's going"?

Dr. PEWITT. The practicalities are that within a department with as many diverse activities as the Department has under its scope, there are dog fights that go on all the time, with people grabbing for other program dollars. There is no doubt about that. Those are realities. It's not that the dog fight goes on. It's the outcome that counts. We have a Secretary that I am very pleased to work for, a man who has spent an enormous amount of time to get familiar with the programs in the Department, probably knows more now in this short period of time about the programs in the Department than any previous Secretary. I am very comfortable with his final call on what we do about fusion.

Mr. LUJAN. Is it fair to ask you what you're recommending?

Dr. PEWITT. No, it's not fair.

Mr. LUJAN. It's not fair. OK.

Thank you, Mr. Chairman.

Mr. YOUNG. Mr. Lowery.

Mr. LOWERY. Mr. Chairman, needless to say I have further questions, but until that magic date of March 10 we are not going to know the specifics or the degree of commitment that the administration has to this program, so I'll defer until that time when we can see some concrete figures.

Mr. YOUNG. Let me ask one more question: If funding were made available are there any scientific obstacles that would stand in the way of proceeding with the design of the fusion engineering device?

Dr. PEWITT. I think I've answered the questions about the technical background. Certainly no official of the Department will be supporting funding above whatever the President requests when our request comes over here to you.

Mr. LUJAN. Or lower?

Dr. PEWITT. Or lower. The number will be precisely correct, whatever it is.

Mr. YOUNG. Does anybody else have any other questions?

[No response.]

Mr. YOUNG. Dr. Pewitt, thank you very much, and Mr. Kintner.

Dr. PEWITT. Thank you for the opportunity.

[Whereupon, at 11:55 a.m., the subcommittee was adjourned.]

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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## THURSDAY FEBRUARY 26, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 9 a.m., in room 2247, Rayburn House Office Building, Hon. Marilyn Lloyd Bouquard (chairman of the subcommittee) presiding.

Mrs. Bouquard. Good morning. I am Congresswoman Marilyn Lloyd Bouquard, the chairman for the Subcommittee on Energy Research and Production. We wish to welcome our witnesses to the hearing this morning.

We are here today to receive testimony on a bill of considerable significance to the nuclear energy program of the Nation. This bill, the Nuclear Waste Research, Development and Technology Demonstration Act of 1981 was introduced by Congressman Goldwater, Congressman Fuqua, myself, and Congressman Lujan, the ranking Republican member of this subcommittee.

The bill directs the Secretary to select two sites and to initiate small-scale research, development and technology demonstration of nuclear waste isolation to build public confidence in the fact that the technology for permanent disposal is well in hand. A small quantity of high-level nuclear waste would be solidified into a glass-like form and placed in containers designed to last as long as it takes for the wastes to decay to safe levels. In this way, the containers and the other components of the containment systems or engineered barriers, as they are technically called, will provide the initial protection for isolating the wastes. The geology deep underground will provide additional isolation. The repository system composed of engineered barriers and surrounding geological protection would then provide a level of isolation equal to or greater than that provided by the original uranium ore body.

The bill provides that the first demonstration facility will be in operation by the end of fiscal year 1987 and the second by the end of fiscal year 1988. An important part of this bill is that it prohibits expansion of these facilities into permanent commercial high-level waste disposal repositories.

As many of you know, technical demonstration of nuclear waste disposal is a key element in freeing nuclear power from the political and institution morass that has engulfed it for the past several years. With the technology that the vast majority of scientists agree is now available, there is no excuse for not promptly demonstrating to the people of the United States that nuclear wastes can be disposed of safely and effectively. At the same time, valuable experience and data will be gained for building, licensing and operating commercial repositories.

This morning we are pleased to have witnesses from the academic community, the nuclear utility industry, and the environmental community. Our witness from the academic community is Dr. Paul Witherspoon, professor of geological engineering at the University of California and associate director and head of the earth sciences division at Lawrence Berkely Laboratory. We have with us, representing the utility industry, Mr. R. Greg Snipes. He is from Duke Power, and is head of the high-level waste task force of the utility nuclear waste management group. Mr. Snipes represents about 39 utilities. Accompanying Mr. Snipes is Dr. Joe Lieberman, who is vice president of the Nuclear Safety Associates, Inc. The environmental community is represented by Mr. David Berick of the Environmental Policy Center in Washington, D.C.

We will have a second panel this morning that will discuss the high temperature gas-cooled reactor—HTGR—program and the viability of this approach. We will have more to say about that program when we introduce the second panel, but I think we will begin, and we will hear a little bit later from Congressman Manuel Lujan, who I think will make an opening statement when he is here.

So we would welcome our first group of panelists.

Gentlemen?

Dr. Witherspoon, I think you drew first. Please, proceed.

## STATEMENT OF DR. PAUL A. WITHERSPOON, UNIVERSITY OF CALIFORNIA

Dr. **Witherspoon**. Madam Chairman Bouquard, I am very pleased to have this opportunity to appear before the Subcommittee on Energy Research and Production of the House Committee on Science and Technology and to testify on the bill, Nuclear Waste Research, Development and Technology Demonstration Act of 1981, H.R. 1909. I believe we all agree that permanent and safe disposal of nuclear waste away from the biosphere is one of the critical problems facing this country that must be solved in a practicable manner. I have been working on this problem over the past four years and have directed the operation of a major underground test facility to investigate some of the key questions that must be resolved. On the basis of my observations, I am convinced that geologic disposal of nuclear waste deep in the underground can become a safe and practical solution to this important problem.

A principal attribute of deep geologic disposal of high-level waste is the high degree of physical inaccessibility it provides against human activities and natural events. However, transport to the biosphere even in a geologically suitable area may occur via groundwater. There are therefore a number of attributes that the rock repository at any potential site should have: A dense material with low seepage rates, a low driving force, and a high capacity to chemically retain the waste products. The generation of heat by the high level radioactive waste also introduces the requirement of chemical and mechanical stability under the controlling rock stresses. Basic questions concerning the effectiveness of different rock types to safely isolate wastes underground over extremely long time periods arise in the selection and characterization of any potential repository site.

We have been able to focus on some of these key questions in recent work at the Lawrence Berkeley Laboratory. Four years ago, our group was assigned the responsibility of working with the Swedish Government in developing the "Swedish-American Cooperative Program on Radioactive Waste Storage in Mined Caverns in Crystalline Rock." Lead organizations are KBS, the nuclear fuel safety program for Sweden, and LBL under the Battelle Office of Nuclear Waste Isolation for the U.S. Department of Energy. Over the past 3 years, thermomechanical, fracture hydrology, and geochemical investigations have been conducted at a depth of 340 meters below surface in a granite rock mass adjacent to a depleted iron ore mine at Stripa, about 150 km west of Stockholm. A series of 31 reports have now been published to document the details of this comprehensive series of investigations, and a dozen more reports are in preparation. A list of these publications is given in Appendix A. I would only bring one set of these reports for the Committee because of the bulk of these; but, if the Committee wishes to have more copies of this, we will be more than happy to provide them.

Mrs. **Bouquard**. Thank you very much. We are very happy to have your copy.

Dr. **Witherspoon**. I think you will find them very interesting reading.

A lead article has just been published in the February 27 issue of Science entitled, "Geological Storage of Radioactive Waste: Results of Field Investigations at Stripa, Sweden," by P. A. Witherspoon, N. G. W. Cook, and J. E. Gale, and summarizes our findings to date.

The principal conclusion from these investigations is that a number of questions with regard to the basic nature of the rock system have been raised for which answers cannot be found in terms of current experience. These problems will require investigations to be conducted in full scale underground test facilities at the depths and other conditions that are expected to be encountered in an actual repository. For speed and economy, preference may be given to the process of evaluating a repository site on the basis of detailed exploration and testing carried out at the surface or in boreholes drilled from the surface. Such techniques, however, cannot yield the data needed to assess the total behavior of crystalline rock masses when subjected to the perturbations of an underground high-level waste repository. Experience with underground experiments at Stripa indicates that site evaluation must include extensive subsurface investigations carried out in conjunction with measurements made at the surface. Much effort is needed at this stage to generate the technology that is required.

I turn now to the specific questions that I was asked to consider.

One. What actions should be undertaken to focus the Department of Energy's program on permanent disposal of high-level radioactive waste?

My general answer is outlined above. The technology required to be able to assess the total behavior of rock masses when subjected to the perturbations caused by high level waste will require underground investigations in a test facility. A much more detailed analysis is given in the science article mentioned earlier. Under the heading, "Importance of Full Scale Field Testing."

Two. Does the bill, Nuclear Waste Research, Dvelopment and Technology Demonstration Act of 1981, H.R. 1909, provide the needed focus? If not, what changes would you recommend?

I strongly support the concept that, to generate the technology needed for permanent disposal of high level waste, the focus must be on the appropriate use of underground test facilities. I would like to make two comments, however.

First, I gathered the impression that H.R. 1909 relies very much on engineered barriers, and I interpret that to mean that the geologic barrier, being more difficult to deal with, cannot be relied upon with the same level of confidence as the engineered barriers. Based on my experience in working on a wide variety of underground engineering problems over the past 40 years, it is my judgment that geologic barriers, such as very low permeability rocks, are at least as effective as engineered barriers. I would therefore urge that the focus of this bill place equal weight on the utilization of both types of barriers.

Second, H.R. 1909 does not mention the present program of the Department of Energy to find four to five repository sites by 1985 and to proceed to have the first repository in operation sometime between 1997 and 2000. I hope I am correct in assuming that the implementation of this bill will not act so as to cause delays in the present program of the Department of Energy.

Three. If a demonstration R. & D. facility were constructed for the emplacement of a minimum of 20 metric tons of waste, would this satisfy the requirements for demonstrating the closure of the fuel cycle?

From the technical standpoint—and I emphasize the technical standpoint—I do not think placing waste underground in a test mode is necessary. You are all aware that waste was stored in a retrievable mode at salt vault 15 years ago and that spent fuel is currently so stored at the Nevada test site. If these demonstrations are not deemed adequate, I do not see how the proposed underground emplacement of 20 metric tons of waste would add to the general argument that this kind of demonstration is needed. Furthermore, in pursuing this kind of logic, it may become necessary to have a technology demonstration facility actually in operation at the first repository site in order to demonstrate closure of the fuel cycle.

Madam Chairman, that completes my statement.

[The prepared statement of Dr. Witherspoon follows:]

# TESTIMONY OF PAUL A. WITHERSPOON

ON BILL H.R. 1909

"Nuclear Waste Research, Development, and
Demonstration Act of 1981"

February 26, 1981

Madam Chairman Bouquard, I am very pleased to have this opportunity to appear before the Subcommittee on Energy Research and Production of the House Committee on Science and Technology and to testify on the bill, Nuclear Waste Research, Development and Technology Demonstration Act of 1981, H.R. 1909. I believe we all agree that permanent and safe disposal of nuclear waste away from the biosphere is one of the critical problems facing this country that must be solved in a practicable manner. I have been working on this problem over the past four years, and have directed the operation of a major underground test facility to investigate some of the key questions that must be resolved. On the basis of my observations, I am convinced that geologic disposal of nuclear waste deep in the underground can become a safe and practical solution to this important problem.

A principal attribute of deep geologic disposal of HLW is the high degree of physical inaccessibility it provides against human activities and natural events. However, transport to the biosphere even in a geologically suitable area may occur via groundwater. There are therefore a number of attributes that the rock repository at any potential site should have: a dense material with low seepage rates (permeability), a low driving force (hydraulic gradient), and a high capacity to chemically retain the waste products (sorption). The generation of heat by the high level radioactive waste also introduces the requirement of chemical and mechanical stability under the controlling rock stresses. Basic questions concerning the effectiveness of different rock types to safely isolate wastes underground over extremely long time periods arise in the selection and characterization of any potential repository site.

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The principal conclusion from these investigations is that a number of questions with regard to the basic nature of the rock system have been raised for which answers cannot be found in terms of current experience. These problems will require investigations to be conducted in full scale underground test facilities at the depths and other conditions that are expected to be encountered in an actual repository. For speed and economy, preference may be given to the process of evaluating a repository site on the basis of detailed exploration and testing carried out at the surface or in boreholes drilled from the surface. Such techniques, however, cannot yield the data needed to assess the total behavior of crystalline rock masses when subjected to the perturbations of an underground HLW repository. Experience with underground experiments at Stripa indicates that site evaluation must include extensive subsurface investigations, carried out in conjunction with measurements made at the surface. Much effort is needed at this stage to generate the technology that is required.

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My general answer is outlined above. The technology required to be able to assess the total behavior of rock masses when subjected to the perturbations caused by HLW will require underground investigations in a test facility. A much more detailed analysis is given in the report in Appendix B. under the heading, Importance of Full Scale Field Testing.

2. *Does the bill, Nuclear Waste Research, Development and Technology Demonstration Act of 1981, H.R. 1909, provide the needed focus? If not, what changes would you recommend?*

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First, I gathered the impression that H.R. 1909 relies very heavily on engineered barriers, and I interpret that to mean that the geologic barrier, being more difficult to deal with, cannot be relied upon with the same level of confidence as the engineered barriers. Based on my experience in working on a wide variety of underground engineering problems over the past 40 years, it is my judgement that geologic barriers, such as very low permeability rocks, are at least as effective as engineered barriers. I would therefore urge, that the focus of this bill place equal weight on the utilization of both types of barriers.

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## PAUL A. WITHERSPOON

### Title

Professor of Geological Engineering, Department of Materials Science and Mineral Engineering, University of California, Berkeley.
Head, Earth Sciences Division, Lawrence Berkeley Laboratory.
Associate Director, Lawrence Berkeley Laboratory, University of California, Berkeley.

### Education

B.S., Petroleum Engineering, University of Pittsburgh, 1941.
M.S., Petroluem Engineering Physics, University of Kansas, 1951.
Ph.D., Geology and Physical Chemistry, University of Illinois, 1957.

### Experience

| | |
|---|---|
| 1941-1949 | Engineer, Phillips Petroleum Company, Bartlesville, Oklahoma, and various other locations |
| 1949-1951 | Graduate student and part-time instructor in petroleum engineering, University of Kansas, Lawrence. |
| 1951-1957 | Head of Petroleum Engineering Division, Illinois State Geological Survey, Urbana. |
| 1957-1965 | Professor of Petroleum Engineering, University of California, Berkeley. |
| 1965-- | Professor of Geological Engineering, University of California, Berkeley. |

### Research Interests

Flow of fluids in porous and fractured rocks
Regional groundwater flow
Underground storage of radioactive waste
Underground storage of fluids
Geothermal systems

### Books

Geochemical Prospecting for Petroleum by A. A. Kartsev, Z. A. Tabasaranskii, M. I. Subbota, and G. A. Mogilevskii, English translation edited by Paul A. Witherspoon and William D. Romey, University of California Press, 1959.

Interpretation of Aquifer Gas Storage Conditions from Water Pumping Tests by P. A. Witherspoon, I. Javandel, S. P. Neuman, and R. A. Freeze, American Gas Association, 1967.

### Publications and Reports

Over 190 publications and reports covering wide range of subjects on underground engineering problems.

# APPENDIX A.

## SWEDISH-AMERICAN COOPERATIVE PROJECT
## TECHNICAL REPORTS

The reports listed below are part of a series documenting the results of the Swedish-American cooperative research program in which the cooperating scientists explore the geological, geophysical, hydrological, geochemical, and structural effects anticipated from the use of a large crystalline rock mass as a geologic repository for nuclear waste. This program has been sponsored by the Swedish Nuclear Power Utilities through the Swedish Nuclear Fuel Supply Company (SKBF), and the U.S. Department of Energy (DOE) through the Lawrence Berkeley Laboratory (LBL).

If you are interested in receiving copies of any of the reports listed below, please indicate which report(s) you wish to receive in the space provided and mail the form to the address indicated on the opposite side.

Swedish-American Cooperative Project technical reports published to date:

1. Swedish-American Cooperative Program on Radioactive Waste Storage in Mined Caverns by P.A. Witherspoon and O. Degerman. (LBL-7049, SAC-01) ____
2. Large Scale Permeability Test of the Granite in the Stripa Mine and Thermal Conductivity Test by Lars Lundstrom and Haken Stille. (LBL-7052, SAC-02) ____
3. The Mechanical Properties of the Stripa Granite by Graham Swan (LBL-7074, SAC-03) ____
4. Stress Measurements in the Stripa Granite by Hans Carlsson (LBL-7078, SAC-04) ____
5. Borehole Drilling and Related Activities at the Stripa Mine by P.J. Kurfurst, T. Hugo-Persson, and G. Rudolph (LBL-7080, SAC-05) ____
6. A Pilot Heater Test in the Stripa Granite by Hans Carlsson (LBL-7086, SAC-06) ____
7. An Analysis of Measured Values for the State of Stress in the Earth's Crust by Dennis B. Jamison and Neville G. W. Cook (LBL-7071, SAC-07) ____
8. Mining Methods Used in the Underground Tunnels and Test Rooms at Stripa by B. Andersson and P.A. Halen (LBL-7081, SAC-08) ____
9. Theoretical Temperature Fields for the Stripa Heater Project by T. Chan, Neville G. W. Cook, and C.F. Tsang (LBL-7082, SAC-09) ____
10. Mechanical and Thermal Design Considerations for Radioactive Waste Repositories in Hard Rock. Part I: An Appraisal of Hard Rock for Potential Underground Repositories of Radioactive Waste by Neville G. W. Cook; Part II: In Situ Heating Experiments in Hard Rock: Their Objectives and Design by Neville G. W. Cook and P.A. Witherspoon (LBL-7073, SAC-10) ____
11. Full-Scale and Time-Scale Heating Experiments at Stripa: Preliminary Results by Neville G. W. Cook and Michael Hood (LBL-7072, SAC-11) ____
12. Geochemistry and Isotope Hydrology of Groundwaters in the Stripa Granite: Results and Preliminary Interpretation by P. Frtiz, J.F. Barker, and J.E. Gale (LBL-8285, SAC-12) ____
13. Electrical Heaters for Thermo-Mechanical Tests at the Stripa Mine by R.H. Burleigh et. al (LBL-7063, SAC-13) ____
14. Data Acquisition, Handling, and Display for the Heater Experiments at Stripa by Maurice B. McEvoy (LBL-7062, SAC-14) ____
15. An Approach to the Fracture Hydrology at Stripa: Preliminary Results by J.E. Gale and P.A. Witherspoon (LBL-7079, SAC-15) ____
16. Preliminary Report on Geophysical and Mechanical Borehole Measurements at Stripa by P. Nelson et al. (LBL-8280, SAC-16) ____
17. Observations of a Potential Size-Effect in Experimental Determination of the Hydraulic Properties of Fractures by P.A. Witherspoon, C.H. Amick, J.E. Gale, and K. Iwai (LBL-8571, SAC-17) ____
18. Rock Mass Characterization for Storage in Nuclear Waste in Granite by P.A. Witherspoon, et al. (LBL-8570, SAC-18) ____
19. Fracture Detection in Crystalline Rock Using Ultrasonic Shear Waves by K.H. Waters, S.P. Palmer, and W.F. Farrell (LBL-7051, SAC-19) ____
20. Characterization of Discontinuities in the Stripa Granite--Time Scale Heater Experiment by R. Thorpe (LBL-7083, SAC-20) ____
21. Geology and Fracture System at Stripa by A. Olkiewicz, J.E. Gale, R. Thorpe, and B. Paulsson (LBL-8907, SAC-21) ____
22. Calculated Thermally Induced Displacements and Stresses for Heater Experiments at Stripa by T. Chan and N.G.W. Cook (LBL-7061, SAC-22) ____
23. Validity of Cubic Law for Fluid Flow in a Deformable Rock Fracture by P.A. Witherspoon, J. Wang, K. Iwai & J.E. Gale (LBL-9557, SAC-23) ____
24. Determinatioin of In-Situ Thermal Properties of Stripa Granite from Temperature Measurements in the Full-Scale Heater Experiments, Pt. I: Methods and Primary Results by T. Chan, J. Jeffry, N.G.W. Cook and P.A. Witherspoon (LBL-8424, SAC-24) ____

25. Instrumentation Evaluation, Calibration, and Installation for Heater Tests Simulating Nuclear Waste in Crystalline Rock, Sweden by T. Schrauf, et al.(LBL-8313, SAC-25)

26. Part I: Some Results from a Field Investigation of Thermo-Mechanical Loading of a Rock Mass When Heater Canisters are Emplaced in the Rock. Part II: The Application of Field Data from Heater Experiments Conducted at Stripa, Sweden for Repository Design by M. Hood, H. Carlsson, and P.H. Nelson (LBL-9392, SAC-26)

27. Progress with Field Investigations at Stripa by P.A. Witherspoon, N.G.W. Cook and J.E. Gale (LBL-10059; SAC-27)

* 28. A Laboratory Assessment to the Use of Borehole Pressure Transients to Measure the Permeability of Fractured Rock Masses by C.B. Forster and J.E. Gale (LBL-8674; SAC-28)

29. Thermal and Thermomechanical Data from In Situ Heater Experiments at Stripa, Sweden by T. Chan, et al., (LBL-11477, SAC-29)

* 30. The Effect of Radon Transport in Groundwater Upon Gamma Ray Borehole Logs by P. Nelson, R. Rachiele, and A. Smith (LBL-11180, SAC-30)

* 31. Strength and Permeability Tests on Ultra-Large Stripa Granite Core by R. Thorpe, D.J. Watkins, W.E. Ralph, R. Hsu, and S. Flexser (LBL-11203, SAC-31)

*in press.

Please type or print

Mail to: Laurel L. Egenberger
Bldg. 90, Room 1070
Lawrence Berkeley Laboratory
One Cyclotron Road
Berkeley, California 94720

NAME________________________________________

ADDRESS_____________________________________

APPENDIX B

Submitted to SCIENCE

# GEOLOGIC STORAGE OF RADIOACTIVE WASTE: RESULTS OF FIELD INVESTIGATIONS AT STRIPA, SWEDEN

P. A. Witherspoon, N.G.W. Cook and J. E. Gale

SUMMARY Access to a granitic rock mass adjacent to a depleted iron ore mine in Sweden has provided a unique opportunity to conduct a comprehensive suite of underground hydrological and thermo-mechanical experiments related to the geologic disposal of radioactive waste. Results of these field tests have shown the importance of geologic structure and the significant differences between published values for the thermo-mechanical properties of granitic rocks and those measured in field tests. To develop valid predictive models for the response of a rock mass to the perturbations resulting from developing a repository, and emplacing sources of heat, it is of vital importance to be able to carry out large scale investigations in the underground. To characterize the site fully, measurements made from the surface will have to be supplemented by extensive subsurface measurements and experiments. Much effort is needed at this stage to generate the technology required for these underground experiments and for the development of a repository.

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P.A. Witherspoon is Professor of Geological Engineering and Head of the Earth Sciences Division, Lawrence Berkeley Laboratory, University of California, Berkeley; N.G.W. Cook is Professor of Mining Engineering, University of California, Berkeley; and J.E. Gale is Associate Professor of Geological Engineering, University of Waterloo, Canada.

## INTRODUCTION

Safe disposal of hazardous materials has become a topic of significant concern in the U.S., particularly within the past decade. Disposal of radioactive waste has aroused much scrutiny both from the technical community and the general public although it is only one part of the entire problem.

Radioactive wastes have special properties, however, which distinguish them from other hazardous wastes. Nuclear wastes range from dilute and short-lived materials to "high level wastes" (HLW), that is, wastes either in the form of spent fuel rods or the products from the first cycle of reprocessing such rods(1). High level wastes are intensely radioactive and produce significant quantities of heat as a result of radioactive decay. The rates of radioactive decay, which usually decrease the biological hazard of the wastes with time, depend upon the form of the HLW.

This article is concerned with the geologic aspects of storing HLW underground. Most current plans for disposal contain a multiple-barrier approach(2). In this approach, redundant components are built into an underground system to serve as barriers to the migration of groundwater and waste. The multiple barriers include: (a) the waste form itself, (b) the canister in which the waste will be contained, (c) the backfilling material used to surround and isolate the canister, and (d) the geologic system surrounding the canisters. All components should be readily characterizable, although the geologic system tends to lack this quality. Ultimately, the ability to characterize the geologic system may dictate the choice of the best host rock for a repository and the disposal system.

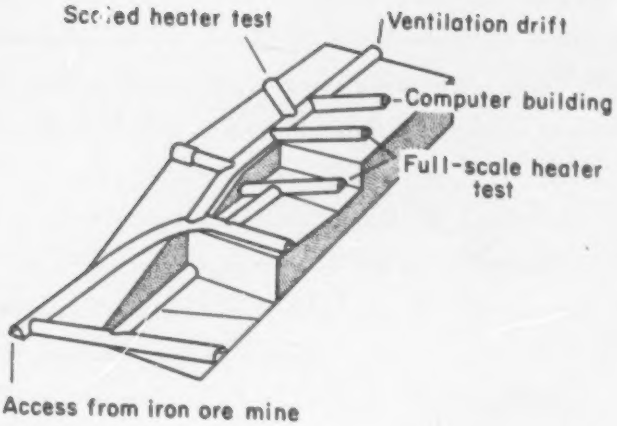
A principal attribute of deep geologic disposal of HLW is the high degree of physical inaccessibility it provides against human activities and natural events. However, transport to the biosphere even in a geologically suitable area may occur via groundwater. There are therefore a number of attributes that the rock repository at any potential site should have: low permeability, low interconnected porosity, low hydraulic gradient, and a high capacity for sorption. The generation of heat by the waste also introduces the requirement of chemical and mechanical stability under the controlling stress fields (both man-made and pre-existing). Basic questions concerning the effectiveness of different rock types to safely isolate wastes underground over extremely long time periods arise in the selection and characterisation of any potential repository site. Although mining and civil enginering provide a wealth of experience concerning underground excavation very little experience exists to guide one in these matters, and there is no general agreement as to the best rock type. Hence, a number of different rock types are currently being considered: plutonic and high grade metamorphics, flood basalts, bedded and domal salt, argillites and tuff.

In mining and civil engineering, economy is maximized to a degree consistent with short-term safety whereas in tha development of a waste repository, safety in both the short- and the long-term must take precedence over economy. A new body of knowledge must be obtained to supplement existing experience through experiments specifically designed to assess the ability of a rock mass to isolate waste at depths typical of proposed repositories. In this article results of recent field experiments are presented and the critical importance of the new technology that must be developed is discussed. The need for a basic understanding of rock behavior under the special conditions that will arise in an underground repository in the presence of heat-generating, radioactive wastes, and the complex processes of waste migration(3) in slowly moving groundwaters cannot be overstated.

## THE FIELD TEST SITE

Over the past three years, thermo-mechanical, fracture hydrology and geochemical investigations have been conducted in crystalline rock at a depth of about 340 meters below surface in Sweden as part of a Swedish-American cooperative program(4). Lead organizations for the study are Karñbranßlesäkerhet (KBS, Nuclear Fuel Safety Program) for Sweden and Lawrence Berkeley Laboratory (LBL) under the Battelle Office of Nuclear Waste Isolation for the U.S. Department of Energy. The experimental program is being conducted in a quartz monzonite rock mass adjacent to a recently depleted iron ore mine at Stripa, about 150 km west of Stockholm. Mining for iron ore at Stripa began in 1485 and continued intermittently until late 1976. The underground workings are 250 km in length on 15 levels down to 410 m below the surface.

The banded hematite ore that was being mined is situated almost entirely in leptite, predominantly a silica-rich, high grade metamorphosed volcanic rock of Precambrian age(5). The leptite was subjected to E-W compression during which the NNE trending Vikern syncline, in which the ore deposit is situated, was formed. Late in a second period of folding, caused by N-S compression, the plutonic rock at Stripa intruded the leptite. The plutonic rock, 1.7 billion years old, is predominantly quartz monzonite and is moderately homogeneous and largely unfoliated. A series of pegmatitic and aplitic dikes transect the reddish, medium-grained massive quartz monzonite. The rock has been fractured in at least two stages, each stage characterized by different fracture-filling minerals. In order to mine the ore, some of the workings intersected the quartz monzonite; hence the easy access for these investigations (Fig. 1).


Scaled heater test
Ventilation drift
Computer building
Full-scale heater test
Access from iron ore mine

XBL 803-6853

Fig. 1. Location of experimental rooms mined in the quartz monzonite rock mass at Stripa some 340 m below surface.

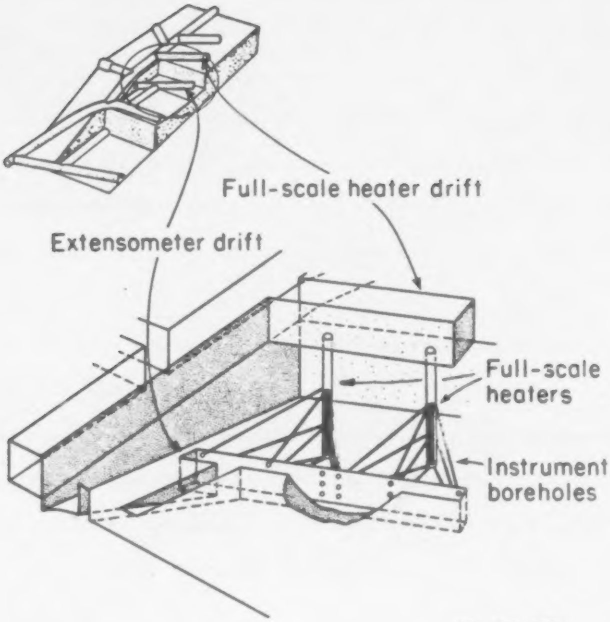
## THERMO-MECHANICAL INVESTIGATIONS

The thermo-mechanical investigations of the Stripa quartz monzonite were designed to study in situ rock behavior at depths below surface comparable with those envisaged for an actual waste repository and under thermal loads similar to that which may be produced by nuclear wastes. The experiments comprised (a) two full-scale heater tests in which the near-field response of the rock mass was studied under simulated short-term and long-term conditions, and (b) an intermediate term, scaled experiment (scaled in time, distance and heat output) which was designed to include thermal interaction between adjacent heaters (Fig. 1). These experiments were instrumented to obtain comprehensive measurements of temperature fields, displacements and stresses as functions of time and space, data needed to test predictions of the thermo-mechanical response of repository rocks.

### Full-Scale Heater Experiments

The energy output from U.S. high level radioactive waste canisters could be as much as 5 kW per canister depending on waste form and age at burial, although the heat output from fresh waste drops significantly in the first few years after removal from the reactor. To determine the maximum safe power output of canisters of radioactive waste, it is important that field experience be gained concerning the thermal and stress effects on the rock immediately adjacent to the canister.

Full-scale heater experiments permitted investigation of the short-term effects of heat on the quartz monzonite. Electric heaters housed in canisters 3 m long and 0.3 m diameter simulated the power output of radioactive waste. Two such canisters were positioned in 406 mm diameter vertical holes drilled to a depth of 5.5 m in the floor of the drift (Fig. 2). These heater


Full-scale heater drift
Extensometer drift
Full-scale heaters
Instrument boreholes

XBL 803-6854

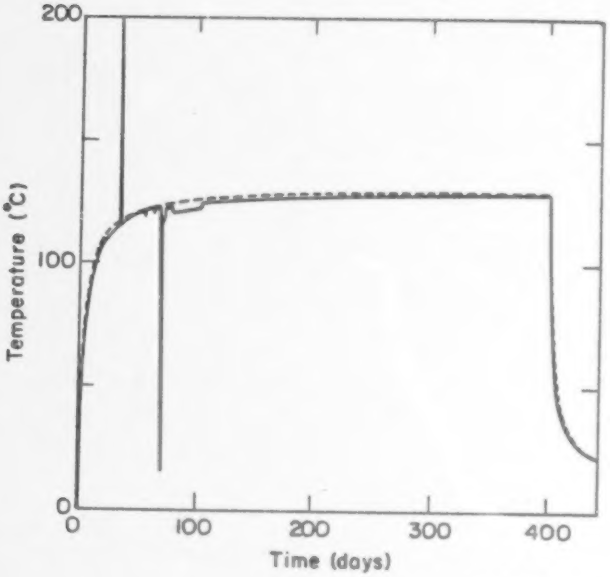
Fig. 2. Arrangement of electric heaters in full-scale experiment showing location of instrument boreholes from adjacent extensometer.

holes were spaced 22 m apart so that the canisters would remain thermally separated from each other for the duration of the experiment. Power output for one canister-heater was adjusted to 5 kW, to simulate the power level of reprocessed waste three years after removal from a light water reactor; power output of the other was set at 3.6 kW to simulate heat from waste approximately five years old at the time of emplacement. These power levels were selected three years ago; currently, significantly lower power levels are preferred.

Response of the rock mass adjacent to these two canisters was monitored extensively. Thermally induced displacements were measured using arrays of multiple-point extensometers, and thermally induced stresses were measured using several USBM borehole deformation gauges and IRAD (Creare) vibrating-wire gauges. Each instrument had a thermocouple associated with it, and many additional thermocouples were positioned around each heater to provide data delineating the temperature field in the rock mass in three dimensions.

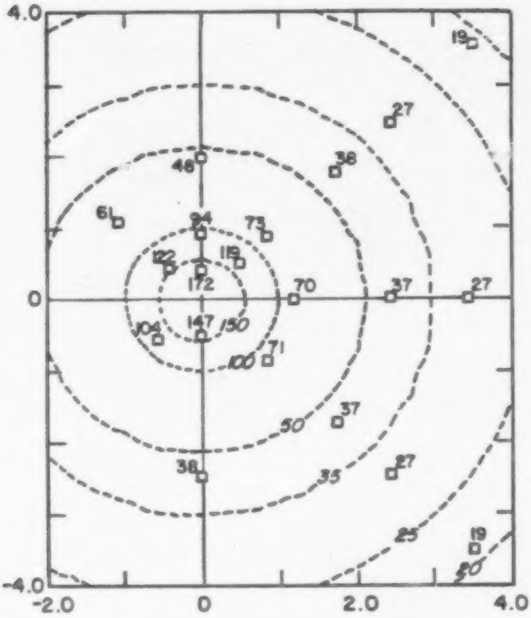
The low thermal conductivity of rock causes temperatures in the immediate vicinity of the heaters, and therefore the temperature gradients within the rock, to approach maximum values in a few months (Fig. 3). The heating lasted 398 days; total monitoring time of this experiment was nearly 1-1/2 years. Initial predictions of temperatures were based on a semi-analytical solution(6) using rock properties from laboratory measurements on intact specimens. The laboratory data used in making these predictions were as follows: density, 2600 kg/m$^3$; specific heat, 837 J/(kg°C); thermal conductivity, 3.2 W/(m°C); and thermal diffusivity, 1.47 x $10^{-6}$m$^2$/sec.

Fig. 4 shows the spatial distribution of temperatures measured on the midplane passing through the center of the 5 kW heater, compared with predicted



XBL 801-4594

Fig. 3. Predicted (dashed line) and measured (solid line) temperatures plotted as a function of time as a radius of 0.4 m from 3.6 kW heater along heater midplane. Variations in measured signals early in the experiment were caused by corrosion of the stainless steel thermocouple sheath.



XBL 791-5319

Fig. 4. Predicted (dashed lines) isotherms and measured temperatures in a horizontal plane through the center of the 5.0 kW full-scaled heater 190 days after starting experiment. Temperatures are in degrees Celsius and distances in meters.

isotherms, at 190 days after initiation of heating. Note the excellent agreement between predicted and measured values in all directions away from the axis of the heater. This is typical of the results that have been obtained throughout both full-scale heater experiments. Despite extensive fractures and joints in the quartz monzonite, the presence of the discontinuities (and the water filling them) had a negligible effect on the temperature field.

### Scaled Heater Experiment

One of the more important factors in repository design is the effect of long-term thermal loading on the rock mass. Calculations show that thermal interactions at the particular power levels under consideration here begin to occur within three years between full-scale canisters spaced 10 m apart in a repository. Thereafter, the effect of individual canisters diminishes and, after 10 to 100 years, maximum temperatures in the plane of the repository are reached and substantial quantities of heat flow upward and downward. Under these conditions, the 100°C isotherm should have migrated approximately 50 m from the plane of the repository, and the resulting thermal expansion of the roughly oblate spheroid of rock at this stage will be about $10^{-3}$, a significant amount.

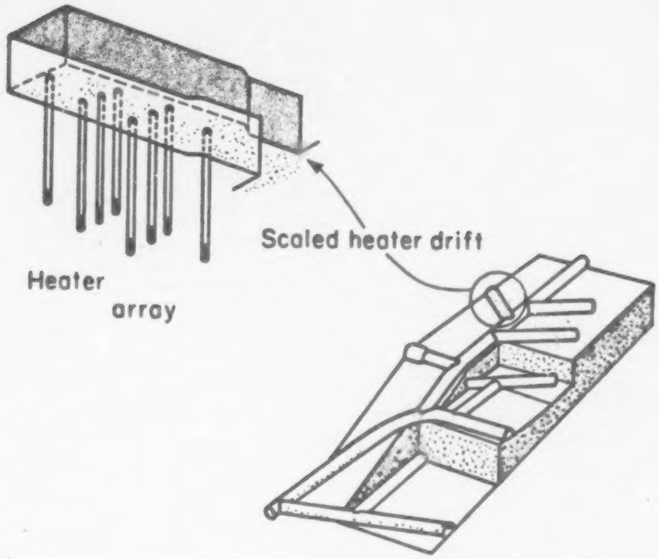
It is impractical to check these thermo-mechanical effects in the critical period from 10 to 100 years using a full-scale heater experiment. Fortunately, the laws of heat conduction allow for compressing the time scale. In the scaled heater experiment at Stripa, times have been compressed in the ratio of 1:10; each year of data from this experiment being equivalent to 10 years of data from the full-scale system. The linear scale, which must be reduced to $1/\sqrt{10} = 0.32$ of the full scale, still allows for realistic dimensions in the field.

An array of 8 heaters, spaced 7 m apart along the axis of a drift and 3 m apart in the direction perpendicular to the axis of the drift, was used for this investigation (Fig. 5). The power output was also scaled appropriately and was progressively lowered during the tests to simulate the decrease in energy output resulting from decay of radioactivity. It was calculated that thermal interaction would occur within a few months of the start of this experiment. Fig. 6 shows how this interaction took place. Predicted isotherms are compared with measured temperatures in a horizontal plane passing through the centers of the heaters 190 days after starting the experiment. As in the case of the full-scale heater experiments, remarkably good agreement was found between measured and predicted rock temperatures.

Rock temperatures in both heating experiments are, in general, symmetrical about the heater midplanes and heater axes, and the heat flow is little affected by discontinuities in the rock mass(7). The dominant mode of heat transfer is by conduction. The temperature field is therefore amenable to prediction using relatively simple semi-analytical methods(6).

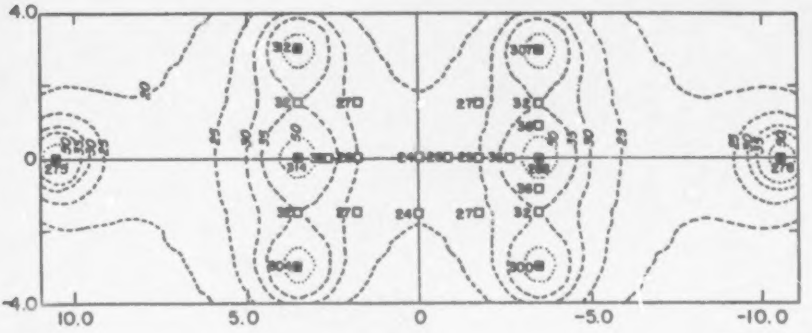
## Rock Displacements and Stresses

Extensometers mounted adjacent to each full scale heater (Fig. 2) yielded results which reveal the complexity of attempting to predict thermomechanical behavior of a discontinuous rock mass. As a first approach, the rock was assumed to be homogeneous and intact, and displacements were predicted prior to heating using the following constant material properties: coefficient of thermal expansion, $\alpha = 11.1 \times 10^{-6}$/°C; Young's modulus, $E = 51.3$ GPa; Poisson's ratio, $\nu = 0.23$; and thermal conductivity, $k = 3.2$ W/(m°C). These values are representative of intact rock as measured in the laboratory over a temperature range of 100-150°C.


Scaled heater drift
Heater array

XBL 785-968A

Fig. 5. Arrangement of 1.0 kW electric heaters in scaled heater experiment. Heaters are 1.0 m in length and have been placed so that the heater midplane is 10.5 m below the floor.



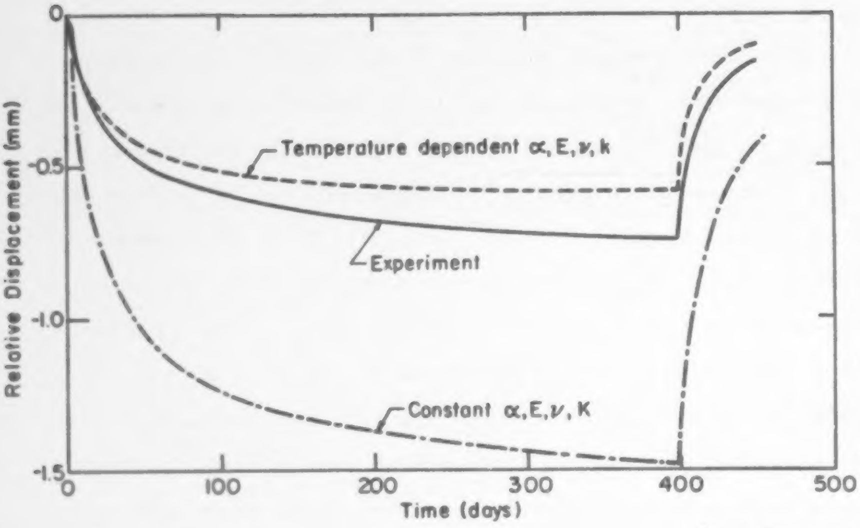
XBL791-5520

Fig. 6. Predicted (dashed lines) isotherms and measured temperatures in a horizontal plane through the center of the scaled heaters 190 days after starting experiment. Temperatures are in degrees Celsius and distances in meters.

The rock displacements show two distinct types of behavior. During the first few weeks, measured displacements were very much less than those predicted by the theory of linear thermoelasticity using the above laboratory values for the thermo-mechanical properties. After the initial period, the measured displacements increased uniformly but at a more or less constant percentage of the predicted values. For many extensometers, the ratio of measured to predicted displacements during this second phase was 0.4 (Fig.7).

An explanation why the experimental results show far less rock movement than predicted from the theory of linear thermoelasticity for intact rock(8), may be the temperature dependence of the thermoelastic properties. Displacements predicted using temperature dependent values of $\alpha$, E, $\nu$, and k for intact rock and based on limited laboratory tests (9) are shown in Fig. 7. Although much better agreement with field data has been obtained, the laboratory values are too few to be regarded as representing the properties of the rock at Stripa sufficiently well. Accordingly, laboratory measurement of the thermo-mechanical properties of the quartz monzonite using samples obtained from a careful core drilling program is receiving high priority.

Measurements of stress changes in the rock mass using vibrating-wire Creare gauges show trends similar to the extensometer results. The observed values of stress were half or less of values predicted initially using linear thermoelasticity with constant values for thermo-mechanical properties. Predicted stresses are still significantly higher than the measured values even after the temperature dependence of rock properties has been taken into account(9). Nevertheless, the stress results support the conclusion from extensometer measurements that thermo-mechanical effects induced in the rock mass are significantly less than predicted by the theory of linear thermoelasticity using published values for the properties of intact laboratory



XBL801-4611

Fig. 7. Measured rock displacements in a vertical direction between anchor points 2.24 m above and below the heater midplane for an extensometer at a radial distance of 1.0 m from the 3.6 kW full-scale heater. Also included are displacements predicted using constant and temperature dependent properties (dashed lines).

specimens of rock. The role of discontinuities in controlling the thermomechanical behavior of rock masses needs much more study.

## Rock Decrepitation

Canisters of sufficient thermal power generate high temperatures in the rock immediately surrounding them. Such heating results in large compressive stresses parallel to the axis, and tangential stresses parallel to the surface of the borehole containing the canister(10). The power levels chosen for the full scale heater experiments enabled the failure of the rock by this mechanism to be studied.

Borescope observations of the holes containing the canisters revealed that minor deterioration of the boreholes began soon after turn on of the heaters. However gross failure of the boreholes by thermal decrepitation occurred only when calculated rock temperatures were in the range of 300-350°C corresponding to values of the thermally induced stresses of the order of the uniaxial compressive strength of the rock. Experimentally determined failure temperature and maximum stress were in good agreement with predicted values. Studies of this mechanism of heat-induced rock failure are continuing.

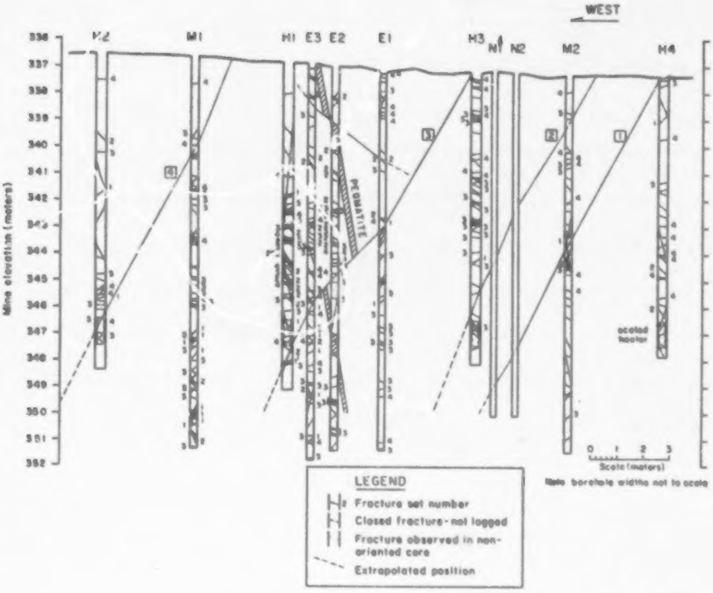
## FRACTURE MAPPING

The disparities between the measured displacements and those predicted using the simple linear theory of thermoelasticity clearly indicate that the quartz monzonite, when subjected to a thermal pulse, does not behave in a linear isotropic manner with constant thermoelastic properties. Discontinuities in the system probably play a major role in controlling thermo-mechanical behavior, but to understand the behavior of the rock mass raises the difficult question of the level of detail at which fracture geometry must be investigated. A comprehensive program of fracture mapping was initiated at the beginning of these experiments in anticipation of the need to answer this question.

The methods employed in studying the fracture system in the scaled heater experiment have been described(11). First, major discontinuities were identified so that they could be modeled as discrete elements(12). Second, all fractures were defined through careful measurement of orientation, spacing, and joint length. It is presently impractical to model such ubiquitous joints as they actually exist; techniques are being developed to represent them stochastically(13, 14).

Since heaters for the scaled experiment were placed 10.5 m below the floor of the drift, only the most prominent and continuous features are likely to persist from the floor through the heated region, as judged from fracture mapping. Accordingly, only the major fractures striking transverse to the drift were extrapolated downward and correlated with discontinuities found in the boreholes. It appears that four shear surfaces probably pass through the heater array (Fig. 8); they offset or truncate other discontinuities, which are filled with chlorite, calcite, epidote, and clay. The most prominent and well-defined fault of the set apparently offsets a pegmatite dike some 20 cm wide.

Statistical analyses of joint geometries using results from logging of underground boreholes and comprehensive surficial mapping of the underground drifts show four distinct sets of joints(11). The directions of three of these sets of joints can be correlated with the directions of the current principal stresses(15). Detailed fracture mapping such as this cannot be accomplished with conventional methods using boreholes drilled from the surface only.


WEST
M2
M1
H1
E3
E2
E1
H3
N1
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M2
H4
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
Mine elevation (meters)
4
3
2
1
PEGMATITE
scaled heater
0
1
2
3
Scale (meters)
Note borehole widths not to scale
LEGEND
Fracture set number
Closed fracture - not logged
Fracture observed in non-oriented core
Extrapolated position

XBL 7811-12833A

Fig. 8. Vertical profile of major fractures along centerline of scaled heater experiments.

## FRACTURE HYDROLOGY

Migration of radionuclides away from a repository may occur by solution in groundwater seeping through the site. The rates of nuclide movement depend on three basic rock properties: (a) permeability, (b) effective porosity, and (c) sorptive properties of the host rock. Thus far, research at Stripa has been concerned only with the first of these three properties.

Evaluating permeability of a rock, such as the quartz monzonite at Stripa, is essentially a problem of understanding the hydraulic behavior of a complex network of fractures. A permeability tensor for the rock mass can be developed from measured orientations and spacings of fractures and an assumed model of aperture distributions. This approach has been used by a number of workers(16, 17, 18, 19).

Basic data on fracture orientations, spacings and continuity have been obtained by mapping the fractures in surface outcrops and underground rooms(11). Data have also been obtained from three boreholes that were drilled from the surface down to the level of the heater experiments at angles of 38° to 45° from the vertical. Each hole was carefully cored so the rock samples could be orientated, and reconstructed to determine fracture geometries. Borehole injection tests have been made to obtain hydraulic measurements of the effective fracture apertures. The surface and subsurface results of mapping are being combined with the borehole data in an attempt to define the permeability tensor for the rock mass(20). This work is not yet complete.

### Large-Scale Permeability Measurement

The above investigations represent the conventional approach to fracture hydrology for a discontinuous rock mass, but the bulk permeability of the

Stripa quartz monzonite is not particularly low. The permeability of the rock mass at a preferred repository site could be two to three orders of magnitude less than the permeability at Stripa. In order to obtain meaningful measurements of such low permeabilities in a very large rock mass, special experiments will be required.

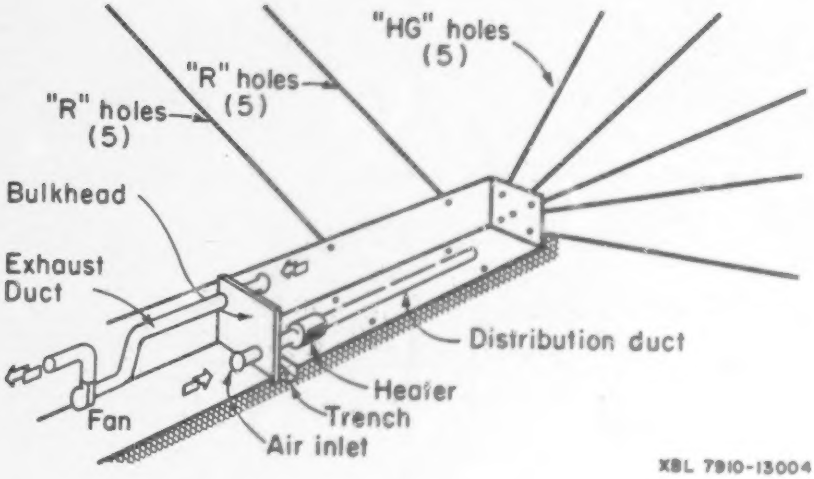
The value of the measured permeability depends upon the volume of rock in which the measurement is made. As the volume of rock sampled increases, the average permeability will oscillate increasing as fractures are included in the measurement and decreasing as solid rock is included. When the volume of rock becomes sufficiently large that permeability is no longer sensitive to the effects of individual fractures, the oscillations will diminish. Increasing the volume may cause additional oscillations, however, if additional fracture systems are encountered. When a single permeability measurement is made on an arbitrary volume of rock, there is no way of knowing *a priori* whether or not the measured permeability lies on an oscillating portion of the curve. A series of measurements on different scales must be made to determine how the permeability of a rock mass changes with the volume over which the measurement is made.

A second problem is to determine the permeability of large rock volumes from *in situ* tests. In homogeneous soils or rocks of high permeability, conventional well tests suffice because they sample a meaningful volume of the system. However, in fractured rocks of very low permeability, such tests affect only the flow system within a few meters of the well and they may not produce meaningful results. The permeability of large volumes of rock may be attempted in two ways: (a) synthesize the desired result from a number of conventional (small scale) tests in boreholes, and (b) create a large scale sink (or source) which will perturb a large volume of the fluid flow system.

A large-scale permeability test is being carried out at Stripa in the ventilation drift shown in Fig. 1(21). A 33 m length of drift has been sealed off and equipped with a ventilation system by which the air temperature can be controlled to evaporate all water seeping into the room (Fig.9). The flow of water into this drift is determined from careful measurements of the air flow rate and the differences in the humidities and temperatures of the entering and exiting air streams. This experiment enables measurements to be made of the average permeability of a large volume of rock of the order of $10^5$ to $10^6$ $m^3$, over a range of air temperatures from about 20°C to 40°C.

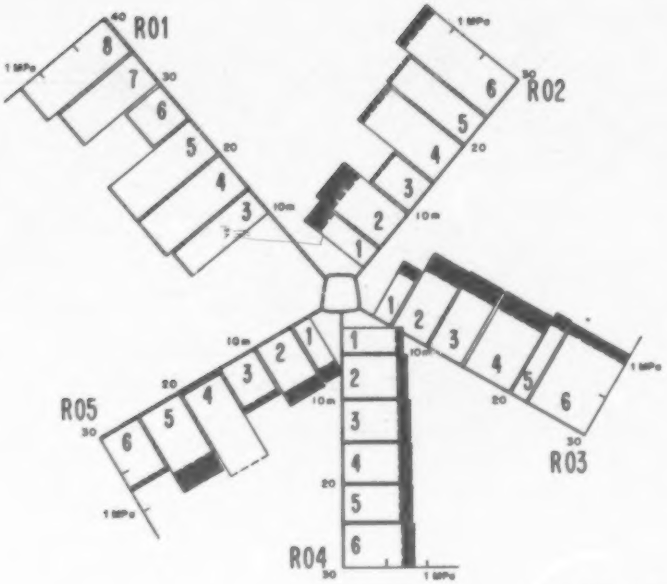
Hydraulic pressures in the rock mass around this drift are measured at 90 points in 15 holes that radiate out from the drift in different directions. Two groups of 5 holes each were drilled radially outward, and one group of 5 holes was drilled at the end of the room to distances of 30 to 40 m (Fig. 9). Fig. 10 shows the orientation of one of the radial groups of boreholes. Each borehole has been sealed off with six packers placed to enable the measurement of pressures and temperatures over five-meter intervals.

Before the installation of packers, all the holes had been draining freely. Borehole R01 (Fig. 10) produced about as much water as all the other 14 holes combined. Earlier injection tests in R01 resulted in pressure responses in many of the other boreholes in the drift; consequently R01 was packed off and instrumented last, so that the effects of the pressure buildup in the other boreholes could be monitored, as shown in Figure 10. The dashed lines represent pressures measured just before R01 was packed off on October 31, 1979. The solid lines represent pressures measured on November 8, 1979, and the stippled areas show how pressure increases occurred more or less


"HG" holes
(5)
"R" holes
(5)
"R" holes
(5)
Bulkhead
Exhaust
Duct
Distribution duct
Heater
Fan
Trench
Air inlet

XBL 7910-13004

Fig. 9. Large-scale permeability experiment in the ventilation drift showing instrumentation boreholes and system to capture water seepage through evaporation into a controlled pattern of air flow.


R01
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10m
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R03
1
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10m
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R04
1
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3
4
5
6
10m
20
30
1 MPa
R05
1
2
3
4
5
6
10m
20
30
1 MPa

XBL 7911-13436

Fig. 10. Pressure measurements in radial boreholes of large-scale permeability experiment at Stripa. Stippled areas show pressure increases eight days after packing off R01. 1MPa = 145 psi.

uniformly throughout this fractured rock after instrumenting R01. Similar effects were noted in all the other boreholes. Note that pressures increase with distance from the drift and are all about 1 MPa (145 psi) at a distance of 30 m from the drift. These unusually low pressures are the result of the effects of drainage into the adjacent mine workings over many years.

After all boreholes were packed off, a marked increase in drips and wet spots in the drift was observed. The temperature and mass flow rate of the circulating air were adjusted, and an initial seepage rate of about 50 ml/min was measured. On the basis of this rate and the observed pressure gradients, a preliminary value for the average hydraulic conductivity of the order of $10^{-11}$ m/s has been calculated. This new method of measuring permeability *in situ* is an important advance in fracture hydrology.

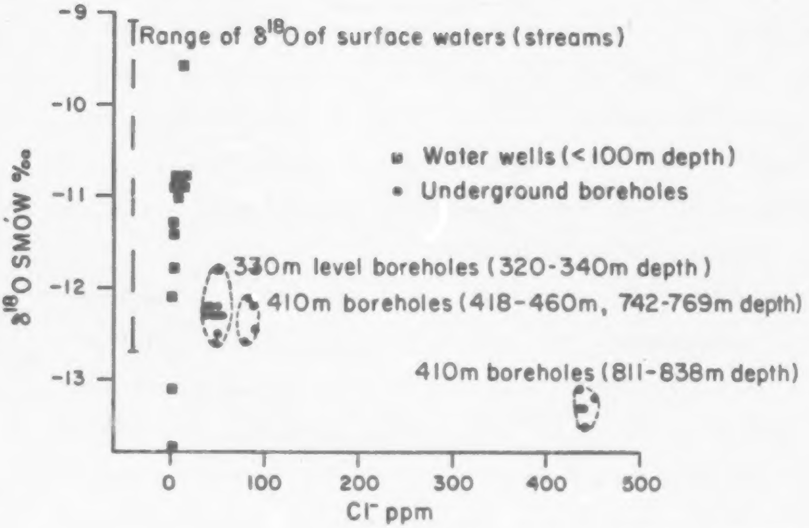
## GEOCHEMISTRY AND ISOTOPE HYDROLOGY

Another important component of the investigations, the geochemistry and isotope hydrology of groundwaters, provides an independent approach to the problem of the overall permeability of a rock system. If there were rapid movement of surface waters to the experimental level (338 m), similarities in chemistry and age between shallow and deep waters should exist. On the other hand, if the deep waters entered the groundwater system many thousands of years ago or at a considerable distance from the present site to which they percolated slowly, there should be significant differences between waters at different depths.

A comprehensive program of investigations on the geochemistry of the Stripa groundwaters has been carried out by Fritz et al.(22). Water samples were collected from the surface, shallow private wells, and boreholes drilled in the heater drifts at the 338 m level. In addition, samples were collected from a deep borehole drilled by the Swedish Geological Survey from 410 m (the deepest operating level in the mine) to about 840 m below surface.

The groundwaters show an increase with depth in calcium, sodium, and chloride. Bicarbonate (or total inorganic carbon) is considerably lower in the deep waters than in surface water. Both magnesium and potassium contents are considerably higher (2-10 ppm) in the shallow groundwaters (<100 m) than in the mine waters (<1 ppm). The pH is about 7.0 in the shallow waters and is as high as 9.8 in the deepest groundwaters (811-838 m). The unusually high pH of the deep water is attributed to greater dissolution at depth of primary silicates, such as feldspars, and the formation of clay minerals. These processes release calcium and thus cause saturation of the mine waters with respect to calcite.

High chloride concentrations and relatively low deuterium and oxygen-18 contents of the deep mine waters, in comparison to near surface waters, indicate that the deep waters had a different source than the near surface waters. The low $\delta^2H$ and $\delta^{18}O$ values indicate that the original surface temperatures of the deep waters were considerably cooler than at present, and the high chloride contents suggest a much different geochemical environment than presently exists at Stripa. This conclusion is substantiated by comparing $\delta^{18}O$ with the chloride concentrations as shown in Fig. 11. It is apparent that the deep groundwaters, especially those at 811-838 m depth, are distinctly different from the shallow groundwaters. This is interpreted as an indication that the different fracture systems are isolated from each other.



XBL 802-8227A

Fig. 11. Comparison of chloride with $\delta^{18}O$ values from geochemical investigations shows that there are distinct differences in the waters at different depths.

Isotope age dating of the various groundwaters was also carried out(22). In contrast to the surface waters where appreciable tritium was observed, the deep groundwaters from the quartz monzonite are essentially devoid of tritium, indicating that the deep waters are older than at least 30-40 years. Waters from the deep levels are also very low in dissolved inorganic carbon, requiring 2000 to 3000 liters of water for $^{14}C$ analysis. Based on this method, the age of these waters at the 330 m level, and probably also from the 410 m borehole, exceeds 20,000 years.

Three different approaches to age dating based on the uranium decay series were investigated also: (a) uranium activity ratios, (b) helium contents, and (c) radium-radon relationships(22). Although the $^{234}U/^{238}U$ ratio method is still under development and subject to some uncertainties, ages exceeding 100,000 years have been inferred from these data. Similar ages have been determined from the $^{4}He$ concentrations. Based on a method proposed by Marine(23) relating $^{4}He$ to its parent $^{238}U$, ages computed from these data ranged from tens of thousands to hundreds of thousands of years. The results of the radium-radon method indicate ages for the groundwaters ranging from 10,000 to 35,000 years.

These data support the concept that the waters presently found in the quartz monzonite rock mass at Stripa, especially at the deepest levels (811-838 m), are indeed many thousands of years old. Also they support the interpretation of the apparent isolation between shallow and deep groundwaters inferred from the geochemical differences cited above. It is apparent that geochemical and isotope hydrology investigations provide an independent approach to evaluating the degree of isolation that exists in a groundwater system.

## IMPORTANCE OF FULL SCALE FIELD TESTING

Important results have been obtained from the investigations at Stripa that would not have emerged unless these experiments had been carried out underground at depths comparable with those envisaged for an actual repository. Experiments at such depths give rise to unexpected and sometimes difficult problems which must be resolved if deep geologic disposal of radioactive waste is to become a reality. Scientific advances are needed in the laboratory but these must be supported by meaningful field experiments.

The behavior (mechanical, thermal, hydraulic, chemical) of a repository in a crystalline rock mass of low permeability is determined by the rock matrix properties and, more importantly, by discontinuities that pervade the rock mass. This raises the first critical question, "Can one determine in sufficient detail the geometry of fractures using surface measurements, that is, measurements made at the surface and in boreholes drilled from the surface?" Although some preliminary studies(24, 25) suggest that fracture orientations between surface and subsurface are similar, there are still no data to demonstrate that the important characteristics of length and continuity of such features can be predicted reliably from surface measurements.

The mapping of fractures must be carried out so that the geometry (orientation, spacing, continuity and aperture distribution) is determined in sufficient detail to enable the total behavior of the rock mass to be predicted. Over long time periods this is a complex problem involving the thermo-mechanical response of the rock system and the hydraulic-chemical behavior of aqueous solutions migrating through the discontinuities. The magnitude of the thermo-mechanical response depends on the thermal loads that are imposed on the system and the material properties of the rock mass. The hydraulic-chemical behavior depends on the permeability and porosity of the system, the hydraulic gradients (natural and/or thermally induced), and geochemical reactions. In addition, both of these coupled effects are affected by the magnitude of the in situ stresses. Isolation requires that the repository be constructed at depths sufficient to keep the fractures closed so as to maintain low permeabilities, even in a perturbed rock mass containing discontinuities, yet not so deep as to generate stresses that cause stability problems.

It is apparent from the thermo-mechanical results obtained thus far at Stripa that much more work will be required to develop a reliable basis for predicting the thermally induced behavior of discontinuous rock masses. The behavior is complex because the mechanical and hydrological effects of the discontinuities are not yet understood. After a repository has been filled with waste canisters, the rock will undergo a thermal pulse of increasing temperature extending out to distances well beyond the limits of the excavations. The magnitude of this effect is, of course, primarily dependent on the energy and spacing of the canisters. However for HLW from light water reactors, this pulse reaches a maximum temperature in the plane of the repository at between 10 and 100 years (26).

This thermal perturbation caused by the repository raises a second critical question, "How should one proceed to develop the technology to reliably predict the global thermal response of a repository in a discontinuous rock mass?" In our view, this can only be carried out in an underground test facility that has been properly designed and instrumented. Whether or not more than one type of crystalline rock needs to be tested underground in this fashion is a question that is difficult to answer because the physics of the thermo-mechanical and hydraulic-chemical behavior of large rock masses is not yet adequately understood. Since granite and basalt have distinctly different types of fracturing and are examples of massive versus bedded forms of igneous rock, they would appear to be prime candidates for underground investigation.

Since the heat output of radioactive waste decays with time, the magnitude of the thermal perturbation depends on how long the emplaced waste was stored at the surface. This raises a third critical question, "What are the tradeoffs between minimizing the thermally induced effects and the option of long term surface storage of waste?" The decrepitation results observed at Stripa when rock temperatures near the 5.0 kW heater exceeded 300°C could undoubtedly be eliminated by keeping the temperatures below some maximum value. This would be an important component of the field experiments suggested above. Low temperatures would also minimize effects on backfill materials and the possibility of generating thermal convection in the groundwater system. In our opinion, a definitive answer to the problem of how long to store waste at the surface in order to minimize thermo-mechanical effects will not be forthcoming until the ability to predict thermally induced effects is perfected through appropriate field tests underground.

Another body of knowledge that must also be developed involves the hydrogeology of the rock mass and the geochemical behavior of aqueous solutions, including radionuclides, as they migrate through that mass. This hydraulic-chemical response is coupled to the thermo-mechanical response through the discontinuities. Fractures in any type of rock will deform under the influence of changes in rock stress. As they deform, the permeability of the rock mass will be affected. The magnitude of these changes in permeability may be very important and will depend on the effects of the thermal perturbation as well as the disturbance caused by the excavation itself.

All of these concerns raise a fourth critical question, "How should one measure rock properties in the field that are necessary to understand the hydraulic-chemical effects?" The properties that one needs are: (a) permeability (hydraulic conductivity), (b) both total and effective porosity, and (c) sorption behavior.

At Stripa, a careful measure of the permeability tensor is being attempted using conventional methods in inclined boreholes drilled from the surface. These methods seem to be working well, but the hydraulic conductivity at Stripa is about $10^{-11}$ m/s. Less permeable rock masses may have values two to three orders lower than this, and whether conventional methods will still give reliable results remains to be seen. On the other hand, the large-scale method of measuring permeability(21) should easily be adaptable to rock masses with permeabilities far less than at Stripa. Thus, the accuracy of borehole methods must be assessed by comparison with results from the large-scale method. The latter method will certainly yield a good measure of the bulk permeability in the immediate vicinity of the repository and this information is needed to confirm the degree of isolation at a potential site. Conceptually, one could use this method to measure the permeability of the rock mass around individual drifts during their excavation. However, in the far field where it is not practical to use the large-scale method, one needs to know the reliability of the various borehole testing techniques in measuring permeability.

In a rock mass with very low values of permeability the problem of measuring the effective porosity using in situ tracer tests is not easily resolved. Because they involve large volumes of rock at considerable depth and sufficient in size to be representative of the total mass, the tests may take months to years to complete. Under such circumstances, conventional tracer tests in deep boreholes drilled from the surface are not likely to yield reliable results. On the other hand, an underground room, similar to that at Stripa (Fig. 9), creates significant pressure gradients at the depths where a repository will be constructed. Movement of groundwater through the fracture system toward such an underground opening is greatly enhanced, and tests using tracers can be designed for use in very large volumes of rock. Actual velocities can be measured by introducing such a tracer at a point along a known flow path and observing time of arrival downstream. Although standard borehole tracer tests contribute to an understanding of fracture flow in higher permeability rock masses, it is our conclusion that the only feasible approach in rocks with very low permeabilities is an underground tracer experiment run in conjunction with a large-scale permeability test.

Predicting the geochemical sorption behavior of aqueous solutions of radionuclides in contact with mineral surfaces is complicated by a lack of basic data. Much work is needed on the behavior of the actinide aqueous and solid species that are important in groundwater transport processes; there is also a dearth of information on the potential for actinides to form colloids in groundwater. Recent work(27) suggests that actinides may form complexes with organic materials that occur naturally in groundwater. The movement of dissolved species involves several mechanisms for retardation, such as sorption on mineral surfaces, precipitation, ion exchange, and diffusion into the rock matrix. Because of the small scale of these phenomena, they can be studied very effectively in the laboratory, and a large effort in this direction is now underway. Eventually geochemists will require field tests to validate their laboratory findings. If underground test facilities are already in operation for other purposes, various geochemical tests could be incorporated conveniently; such tests are already being planned for the Stripa project.

The critical importance of being able to determine the velocity of groundwater movement through a rock mass with very low permeability cannot be overstated. A good understanding of the geochemistry and of the ages of the groundwaters at different points in the total system provides important data. There is also the need to integrate geochemical and isotopic data with the physical hydrology results, as is being done at Stripa. This raises a fifth critical question, "How should one gather groundwater samples for these investigations?"

The conventional approach to this problem is to collect water samples in vertical boreholes drilled from the surface. Drilling procedures normally cause contamination of the natural waters because the pressures required for fluid circulation often exceed those of the fluids in the rocks being drilled. This is usually overcome before sampling by producing a sufficient volume of water from such rocks until the contaminants are removed. In rocks with very low permeability this may not be practicable because the influx of groundwater into boreholes may be very slow.

Experience at Stripa, however, has shown clearly the superiority of collecting groundwater samples from boreholes drilled from underground drifts and rooms. Hydrostatic water pressures in rock are about a Megapascal per 100 m of depth, whereas the pressure within the mined openings is only about a tenth of a Megapascal (one atmosphere). Thus, any borehole that is drilled from an underground excavation into the rock mass around the opening encounters hydrostatic pressures that far exceed the pressure necessary to circulate the drilling fluids. This creates an artesian condition that minimizes contamination and greatly simplifies the subsequent problem of collecting water samples. Furthermore, both horizontal and vertical boreholes can be drilled from an underground location to provide data in three-dimensions of the hydraulic environment. This approach to the collection of samples of water for geochemical and isotopic studies of groundwater is far more effective than are methods using boreholes drilled from the surface.

The effectiveness of backfill materials in isolating canisters of radioactive waste and in plugging off underground openings is still another problem that must be investigated. This raises the sixth critical question, "What is the proper way to demonstrate the effectiveness of backfill materials?" As in the case of sorption behavior for aqueous solutions of radionuclides, many fundamental aspects can be investigated very effectively in the laboratory, especially in conjunction with the study of naturally occurring geological materials. A large effort in this direction is already underway. Ultimately, however, field tests will be required to demonstrate how such materials can be used best under repository conditions. It will be necessary to carry out field demonstrations on selected materials under appropriate levels of stress, temperature and moisture content. This can best be done meaningfully only in an underground test facility.

Answers to the above six questions cannot be found in terms of current experience nor through numerical modeling alone; these problems will require investigations to be conducted in full scale underground test facilities at the depths and other conditions that are expected to be encountered in an actual repository. For speed and economy, preference may be given to the process of evaluating a repository site on the basis of detailed exploration and testing carried out at the surface or in boreholes drilled from the surface. Such techniques, however, cannot yield the data needed to assess the total behavior of discontinuous rock masses when subjected to the perturbations of an underground waste repository. Experience with underground experiments at Stripa indicates that site evaluation must include extensive subsurface experiments, carried out in conjunction with measurements made at the surface. Much effort is needed at this stage to generate the technology that is required. The Stripa investigations are a beginning.

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Mrs. BOUQUARD. Thank you very much, Dr. Witherspoon, for your excellent testimony.

We would like to welcome now Congressman Lujan, who is ranking minority member. If you have any opening remarks, we would like to hear from you.

Congressman Lujan?

Mr. LUJAN. Thank you very much, Madam Chairman. I do have an opening statement, and I would like to have it included in the record.

[Opening statement of Mr. Lujan follows:]

### OPENING STATEMENT OF HON. MANUEL LUJAN, JR.

Thank You Madam Chairman. It is important to have these distinguished experts testify today on waste management and on advanced isotope separation. Waste management is perceived by the uninformed public as the unsolved problem that might block the continued use of nuclear energy, contrary to the continued testimony that we receive in the Congress. Previous witnesses have told us that there is no significant technical problem. I hope that we hear today how we can convince the public of this, and how we can move from solving the technical problems to solving the political blocks that seem to stop waste disposal.

It has become evident that engineered barriers are important in making waste disposal safe. Also, putting emphasis on engineered barriers means that the requirements of geology are less, so the Department of Energy activities in doing test drilling around the nation perhaps could be reduced. These drillings needlessly agitate the local people. I hope we can hear about the acceptability of the waste disposal locations that have already been explored.

Public acceptance is important, so negotiations with the local people must be open and sincere. It seems proper that the local people receive incentives. Perhaps we can hear from the witnesses about possibilities of locating the facilities for building the engineered barriers right at the disposal site. This would give local employment, and would involve the local people in the construction that would help assure the safety of disposal.

I hope also that we will hear about alternative methods of spent fuel storage. The spent fuel in the most crowded of the storages at the reactors is very old. It is not as radioactive and it is not as thermally hot as the pool storages were designed for. Maybe alternative storage methods are more appropriate now, methods that could be cheaper and simpler. I hope that we shall hear about methods of dry storage for these alternatives.

Thank you, Madam Chairman.

Mr. LUJAN. I just want to say as part of my opening remarks how important it is for us to move ahead with waste management. We seem to always hear the same argument which is that we don't know what will be done with the waste that is generated, and so we have a lot of opposition because of that. Hopefully, from these hearings, we can move ahead and, hopefully, resolve the problem.

Thank you.

Mrs. BOUQUARD. Thank you very much, Mr. Lujan.

Mr. Goldwater is actually the chief sponsor of H.R. 1909.

Mr. Goldwater, do you have any opening remarks that you would like to make at this time?

Mr. GOLDWATER. Madam Chairman, I really have none. I think these hearings are important. I think we will benefit by this discussion. The more discussion, the better. Discussion will shed light on what is suitable and what is not. It is also important that we recognize the importance of this issue and that we proceed with as much haste as is possible in order to overcome some of the political ramifications that are impacted upon States to participate or to be able to create generating facilities by demonstrating the ability to handle waste.

As I have said before, and it is clearly understood, there is a great deal of pressure on our States and political systems not to allow further development of nuclear energy until we have demonstrated the ability to handle waste material.

Further discussions, further debates, further delay is only going to put off those needed facilities, as well as being able to take care of the fuel rod wastes that is piling up in pools all over this country.

I am just hopeful that this Congress will put in place an accelerated program if for no other reason than to alleviate the political pressures that impact upon this whole nuclear business.

Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much, Mr. Goldwater.

[Mr. Lundine's statement is inserted at this point in the record, pursuant to his unanimous consent request, infra.]

## STATEMENT OF CONGRESSMAN STAN LUNDINE

Madam Chairwoman, I commend your initiative in giving priority attention early in this Congress to the need for a resolution of the nuclear waste disposal problem. I believe the development of a comprehensive and effective policy to dispose of our nuclear wastes has been neglected for too long. I am encouraged by the progress which I believe was made during the last Congress on this issue, both through initiatives coming from this subcommittee and others in the House. We must remain committed to moving forward with an action oriented program in this area. I look forward to working with you and others on this subcommittee in this regard.

I also commend the leadership of you, Madam Chairwoman, and Mr. Goldwater in introducing H.R. 1909, calling for the development of two sites for small-scale facilities for research, development, and demonstration in regard to repository development. There is no question in my mind of the need to take the research heretofore conducted on this problem out of the laboratory and into concrete situations where we can put our technical knowledge to the test.

I have introduced legislation, H.R. 1993, which I hope we will also discuss here today. My legislative proposal is not inconsistent with the approach taken in H.R. 1909, but rather acknowledges the need to integrate the concept of research and development repositories to test and collect data on repository development into an overall comprehensive permanent disposal program.

H.R. 1993 would require that the Department of Energy within a year's time submit to the Congress a Mission oriented plan which links the necessary research and development steps with the framework to implement a permanent program. Such a planning document is a prerequisite to a successful national radioactive waste management program and to insuring that our research and development dollars are utilized in the most effective manner possible in a tight budgetary climate.

In addition, my proposal contains a number of elements which I believe are critical to establishment of an action-oriented and effective national program to deal with our hazardous nuclear wastes. These include:

Time-oriented goals for permanent repository development which should enable us to have either a licensed retrievable intermediate scale repository or a licensed permanent repository operating by the mid 1990's.

Establishment of a credible and workable mechanism for the involvement of states in the repository siting process and for the timely resolution of disputes between the federal government and states.

Establishment of a trust fund drawn from utilities with title to spent fuel to fund implementation of the plan which is developed by the Department of Energy and agreed to by Congress.

Providing the states with repository development located within their borders with payments for utilization of their land for this purpose. The money for such payments would be derived from the utility trust fund.

A demonstration program at utility sites for the interim storage of spent fuel utilizing several "dry storage" technologies which have been under development by other nations and the Department of Energy.

A Congressional policy statement on nuclear reprocessing to eliminate the policy vacillation on this issue. H.R. 1993 would permit the reprocessing of spent nuclear fuel by the private sector, but would prohibit the federal government from providing direct subsidies for such activity or from assuming the task of government reprocessing for commercial purposes.

I look forward to the opportunity to explore all of the elements of H.R. 1993 in greater detail with the members of this subcommittee, with the witnesses we have before us today and those who will testify before us during the course of upcoming authorization hearings on the Department of Energy budget.

Mrs. BOUQUARD. We do have all the written testimony before us and, if any of you would like to summarize your statements, your complete testimony will be a part of the record.

Our next witness is Mr. Greg Snipes, and we certainly welcome you, and you can proceed at this time.

[The biographical sketches of Mr. Snipes and Mr. Lieberman follow:]

### R. GREG SNIPES

R. Greg Snipes, a 1972 graduate of North Carolina State University in Nuclear Engineering, is Systems Engineer, Fuels in Duke Power Company's Steam Production Department. His responsibilities have included nuclear fuel planning and procurement, including contract management, and related fuel performance activities. He currently serves as Chairman of the Utility Nuclear Waste Management Group's High Level Waste Working Group.

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### JOSEPH A. LIEBERMAN

Dr. Lieberman received the Bachelor of Engineering Degree in 1938 from the Johns Hopkins University and the Doctorate of Engineering in 1941 from the same institution. After military service he was employed by the U.S. Atomic Energy Commission where between 1948 and 1968 he was successively Sanitary Engineer; Chief, Environmental and Sanitary Engineering Branch and Assistant Director of Reactor Development for Nuclear Safety. Subsequently he held the positions of Assistant Administrator for Research and Technology of the Environmental Health Service in HEW, Deputy Assistant Administrator for Radiation Programs in EPA, and Senior Specialist in Energy and Environment in the Congressional Research Service. After leaving Government service he was employed by the General Electric Co. as Manager, Environmental Analysis in the Center for Energy Systems.

Since 1976 he has been associated with Nuclear Safety Associates, Inc., a private consulting firm in Bethesda, Md.

## STATEMENT OF R. GREG SNIPES, UTILITY NUCLEAR WASTE MANAGEMENT GROUP

Mr. SNIPES. Thank you.

Madam Chairman and members of the subcommittee, I am pleased to have the opportunity to appear before you today and testify on H.R. 1909, the Nuclear Waste Research, Development and Demonstration Act of 1981.

I am a systems engineer with the Duke Power Co. and, as you have pointed out, Madam Chairman, currently serve as chairman of the high level waste working group of the Utility Nuclear Waste Management Group. To emphasize, again, the UNWMG is a group of 38 publicly owned and investor-owned electric utilities. The UNWMG was formed in 1980 through the merger of two utility groups, both of which had long been active in the field of nuclear waste management. I am also appearing on behalf of the Edison Electric Institute and the American Nuclear Energy Council.

I also have with me today Dr. Joseph A. Lieberman, of Nuclear Safety Associates, Inc. Nuclear Safety Associates—and Dr. Lieberman in particular—have served as consultants to the UNWMG in a number of areas, including those related to high-level radioactive waste.

Let me begin by expressing our appreciation to the subcommittee for its attention to this important matter. Your activities in this area have helped to foster the necessary nuclear waste legislation that is required to achieve an effective and timely research and development program.

Madam Chairman, I might point out at this time that the written statement which you have before you and which we request be made a part of the record is more extensive than my following remarks.

We have been asked to address the following three questions in our testimony:

First, what actions should be undertaken to focus the Department of Energy's program on permanent disposal of high-level radioactive waste?

Second, does the bill, Nuclear Waste Research, Development and Technology Demonstration Act of 1981, H.R. 1909, provide the needed focus? If not, what changes would you recommend?

Third, if a demonstration R. & D. facility were constructed for the emplacement of a minimum of 20 MT of waste would this satisfy the requirements for demonstrating the closure of the fuel cycle?

With respect to the first question, the Federal Government's program for managing high-level waste and spent nuclear fuel over the past 4 years can be characterized as an effort to study an unlimited number of factors, rather than as an effort to implement a specific demonstration program or a final waste repository.

While it is true that, given adequate capacity, continued interim storage of spent fuel and high-level wastes could safely manage the existing and future inventory from commercial nuclear power generation, we must demonstrate that the task of waste disposal can be accomplished. The realities of budget, public perception, and political considerations require that we stop indefinitely studying and deferring the implementation of a waste management program.

As long as DOE continues to examine the numerous possible solutions, budget funding will increase. Moreover, many people will continue to incorrectly perceive that the technical basis for permanently disposing of spent fuel or high-level waste has yet to be discovered.

We believe that the DOE program can and should be brought into sharper focus. Instead of the current emphasis on a multiplicity of unending studies, DOE should tailor its efforts to a near-term goal of placing one or more geologic repositories into operation; and a first step in achieving this is a properly integrated program of demonstration facilities. Not only is this likely to expedite the repository program, it is also likely to cost less for the ratepayer.

With the current data base, DOE should be in a position now to select one or two preferred system designs from among the wide variety being looked at today. What is needed is site specific information and confirmatory data on the performance of a specific repository system.

This brings us to the second question. It is our opinion that H.R. 1909 provides a good mechanism for making the transition from DOE's current study everything mode to a project-oriented mode. As part of an integrated waste management program and assuming appropriate funding, the project provided for in the bill could provide useful, confirming information while, at the same time, demonstrating to the public that geologic disposal is, indeed, achievable.

However, there are specific points in the bill to which we would like to address ourselves.

First, with respect to the findings and purposes set forth in section 2, it might be helpful if the language emphasized that, while research, development and technology and demonstration are important, it is only another step toward the ultimate goal of establishing full-scale repositories. It is extremely important to recognize that DOE should fully integrate these near-term demonstration activities into its overall waste disposal program.

With reference to section 3. we believe that the demonstration facilities provided for in H.R 1909 should not be limited solely to the receipt of solidified high-level wastes. We appreciate and support what we view as the subcommittee's expression that any research, development and demonstration facilities should provide for the receipt of reprocessing waste. However, we believe that the demonstration facilities should be designed for and receive both high-level reprocessing waste and spent fuel.

Section 4 prescribes dates for the operation of the two technology demonstration repository facilities in terms of the end of fiscal years 1987 and 1988. These appear to be easily achievable. We would note, however, that, if sites where substantial information already exists were chosen, the schedule might well be expedited.

With respect to engineered barriers, which are also addressed in section 4, the position of the industry and DOE has been for some time and continues to be that the disposal of high-level wastes must be viewed on an overall systems basis. This approach is recognized in H.R. 1909.

We believe that a rational standard for the waste disposal system should be that people not be exposed to radiation levels as a result of system operation in excess of a fraction of the variations in natural background radiation. It might, therefore, be useful to consider a design lifetime for engineered barriers in the technology demonstration activites which is tied to the period of fission product decay—300-500 years—rather than the time period needed for the health hazards to become comparable to the original ore body.

Turning to the last question, as to whether the implacement of a minimum of 20 metric tons of waste in the proposed technology demonstration facilities would satisfy the requirements for demonstrating the closure of the fuel cycle, in our view it would or, at least, it should. Other segments of the back end of the nuclear fuel cycle, spent fuel reprocessing and high-level waste solidification have already been demonstrated in this country and abroad.

With respect to the waste disposal segment, I have said earlier that we firmly believe the technology exists to enable us to safely accomplish this. The operation of the technology demonstration facilities as proposed would provide further substantial concrete evidence to support this belief and, thus, provide the specific bases for concluding that nuclear fuel cycle closure has been demonstrated.

It is recognized that some States have adopted legislation directly relating to this question. Since their criteria for meeting requirements of demonstration are not clear to us, we cannot say whether our comments on this point reflect satisfaction of those criteria. We suspect, however that, in some instances, nothing short of the actual long-term operation of a full-scale, licensed repository would satisfy the requirements. This interpretation is obviously unreasonable.

In concluding, we would like to reiterate our support for an overall, integrated waste management program culminating in the operation of a full-scale repository. In this regard, the technology demonstration projects provided for in H.R. 1909 would be a valuable program element.

Madam Chairman, we stand ready to assist the subcommittee in any way that we can, including discussions with your staff to further clarify our specific recommendations.

Thank you.

[The prepared statement of Mr. Snipes follows:]

STATEMENT OF

R. GREG SNIPES

CHAIRMAN, HIGH LEVEL WASTE WORKING GROUP

OF THE UTILITY NUCLEAR WASTE MANAGEMENT GROUP

BEFORE

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

FEBRUARY 26, 1980

# Statement of R. Greg Snipes,
Chairman, High Level Waste Working Group
of the Utility Nuclear Waste Management Group
Before Subcommittee on Energy Research and Production
Committee on Science and Technology
U. S. House of Representatives
February 26, 1980

Madam Chairman and Members of the Subcommittee: I am pleased to have the opportunity to appear before you today and testify on H.R. 1909, the "Nuclear Waste Research, Development, and Demonstration Act of 1981."

I am a Systems Engineer with the Duke Power Company, and currently serve as Chairman of the High Level Waste Working Group of the Utility Nuclear Waste Management Group (UNWMG). The UNWMG is a group of 38 publicly-owned and investor-owned electric utilities.*/ The UNWMG was formed in 1980 through the merger of two utility groups, both of which had long been active in the field of nuclear waste management. I am also appearing on behalf of the Edison Electric Institute (EEI), the principal trade association of investor-owned utilities, who generate approximately 77 percent of all electricity and serve 69 million customers in the United States; and on behalf of the American Nuclear Energy Council (ANEC), which represents more than 100 organizations having an interest in nuclear power, including private, public and cooperatively owned utilities, manufacturers, architect-engineers, and various firms in the nuclear fuel cycle.

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*/ Alabama Power Company; Arizona Public Service Company; Baltimore Gas & Electric Company; Boston Edison Company; Carolina Power & Light Company; The Cleveland Electric Illuminating Company; Commonwealth Edison; Consolidated Edison Company of New York; The Detroit Edison Company; Duke Power Company; Duquesne Light Company; Florida Power & Light Company; Florida Power Corporation; Georgia Power Company; Gulf States Utilities Company; Houston Lighting & Power Company; Illinois Power Company; Iowa Electric Light & Power Company; Long Island Lighting Company; Los Angeles Department of Water and Power; Middle South Utilities; Nebraska Public Power District; Niagara Mohawk Power Corporation; Northeast Utilities; Northern States Power Company; Pennsylvania Power & Light Company; Philadelphia Electric Company; Portland General Electric; Power Authority of the State of New York; Sacramento Municipal Utility District; Southern California Edison Company; SNUPPS; Texas Utilities Company; Toledo Edison Company; Virginia Electric & Power Company; Wisconsin Electric Power Company; Wisconsin Public Service Corporation; and Yankee Atomic Electric Company.

I also have with me today Dr. Joseph A. Lieberman of Nuclear Safety Associates, Inc. Nuclear Safety Associates -- and Dr. Lieberman in particular -- have served as consultants to the UNWMG in a number of areas, including those related to high level radioactive waste.

Let me begin by expressing our appreciation to the Subcommittee for its attention to this important matter. Your activities in this area have helped to foster the necessary nuclear waste legislation that is required to achieve an effective and timely research and development program.

As you know, nuclear power is -- and will continue to be for many years to come -- a vital part of this nation's energy resources. Presently, some 11 to 12 percent of our total national output of electricity comes from nuclear power. Today nuclear generating capacity, some 51,000 MWe, exceeds the entire installed electric capacity as it existed in this country just 35 years ago. In addition to the 70 operating nuclear plants, some 90 additional facilities are under construction. When completed, these will add another 100,000 MWe of generating capacity, which will result in an amount of nuclear generation equal to about 30 percent of the national total. The Duke Power Company already has three operating nuclear units totalling about 2,600 MWe, and one 1,150 MWe unit which has recently completed fuel loading. Three additional units, totalling over 3,400 MWe, are scheduled to come on line by the end of 1985. Roughly one quarter of Duke's generation today is nuclear fueled. By 1986 that fraction will increase to about one half.

The reliance on nuclear power in some other areas of the country is even more substantial. This reliance has provided major benefits to the customers of electric utilities in terms of lower rates, diversity of fuel resources, and decreased reliance on imported foreign oil.

Let me now turn to the specific matter at hand. We have been asked to address the following three questions in our testimony:

1. What actions should be undertaken to focus the Department of Energy's program on permanent disposal of high-level radioactive waste?
2. Does the bill, Nuclear Waste Research, Development and Technology Demonstration Act of 1981, H.R. 1909, provide the needed focus? If not, what changes would you recommend?
3. If a demonstration R&D facility were constructed for the emplacement of a minimum of 20 MT of waste would this satisfy the requirements for demonstrating the closure of the fuel cycle?

With respect to the first question, the Federal government's program for managing high level waste and spent nuclear fuel over the past four years can be characterized as an effort to study an unlimited number of factors, rather than as an effort to implement a specific demonstration program or a final waste repository. Prior to 1977, efforts to develop a geologic repository were largely focused on salt as the appropriate medium. This was based on recommendations of the National Academy of Sciences in 1957, 1960, 1966 and 1970. Starting in 1977, there was a major reorientation of the program. DOE was directed to examine many facets of nuclear waste management, including other geologic media.

DOE began to fund an enormous variety of studies on the different components of the repository system. Literally hundreds of millions of dollars each year are being spent on a seemingly endless array of studies. DOE is sponsoring studies on eight or ten waste forms, a dozen or more different canister designs, perhaps half a dozen types of overpack, and half a dozen geologic media. Although the DOE program employs a battalion of scientists and engineers to study waste disposal, thus far the DOE has given little indication that an expeditious choice will be made from among the alternatives being examined.

Continuing study of the numerous options creates no problems in and of itself. While it is true that, given adequate capacity, continued interim storage of spent fuel and high level waste could safely manage the existing and future inventory from commercial nuclear power generation, we must demonstrate that the task of waste disposal can be accomplished. The realities of budget, public perception and political considerations require that we stop indefinitely studying and deferring the implementation of a waste management program. As long as DOE continues to examine the numerous possible solutions budget funding will increase. Moreover, many people will continue to incorrectly perceive that the technical basis for permanently disposing of spent fuel or high level wastes has yet to be discovered. While the scientific community recognizes that such a technical basis already exists, the DOE program is nonetheless viewed in many circles as leaving the opposite impression.

We believe that the DOE program can and should be brought into sharper focus. Instead of the current emphasis on a multiplicity of unending studies, DOE should tailor its efforts to a near-term goal of placing one or more geologic repositories into operation; and a first step in achieving this is a properly integrated program of demonstration facilities. Not only is this likely to expedite the repository program, it is also likely to cost less for the ratepayer.

As a result of the thirty years of scientific studies, we think that the basic technology is in hand. With the current data base, DOE should be in a position now to select one or two preferred system designs from among the wide variety being looked at today. What is needed is site specific information and confirmatory data on the performance of a specific repository system.

This brings us to the second question. It is our opinion that H.R. 1909 provides a good mechanism for making the transition from DOE's current "study-everything" mode to a project-oriented mode. As part of an integrated waste management program, and assuming appropriate funding, the project provided for in the bill could provide useful, confirming information while, at the same time, demonstrating to the public that geologic disposal is, indeed, achievable.

In addition to the highly valuable public perception and public acceptance purposes that would be served by such facilities and their operation, important site-specific data and information would be obtained. This includes the detailed host-rock characteristics at depth; the ability to validate models of near-field phenomena related to thermal and radiation effects and rock mechanics; and waste handling and emplacement techniques. It also would provide a realistic vehicle for various tests, the results of which would provide a firm, realistic basis for the engineering design of a full-scale repository and other parts of the system. Accordingly, we do see the accomplishment of the purposes of this bill as providing integral parts of a mission-oriented waste disposal program. However, there are specific points in the bill to which we would like to address ourselves.

First, with respect to the Findings and Purposes set forth in section 2, it might be helpful if the language emphasized that -- while research, development and technology and demonstration are important -- it is only another step toward the ultimate goal of establishing full-scale repositories. It is extremely important to recognize that DOE should fully integrate these near-term demonstration activities into its over-all waste disposal program. In the Nuclear Regulatory Commission's Waste Confidence Rulemaking, both DOE and UNWMG-EEI, as well as others, have taken the position that the technology exists now for the disposal of high level radioactive wastes in geologic repositories. This, we believe, is also the view expressed in the bill which, in section 2(b)(2), refers to developing engineering experience, data, and information in terms of confirming the existence of technological solutions to the problem of safely disposing of high level radioactive wastes. We believe, however, that section 2 might be clarified further to avoid any doubt as to whether disposal technology currently exists.

Section 3 contains a definition of "'technology demonstration facility' and 'demonstration facility'." We believe that this definition should be modified to state more clearly that a site which is the location of such a facility is not necessarily thereby excluded as the location of a full-scale repository. To avoid any possible confusion, the language of the bill should be revised to make it clear that the location of a technology demonstration facility at a given site does not, in and of itself, disqualify the entire site from potential use as the location of a permanent repository.

In addition, and with reference to this same section 3, we believe that the demonstration facilities provided for in H.R. 1909 should not be limited solely to the receipt of solidified high level waste. We appreciate and support what we view as the Subcommittee's expression that any research, development and demonstration facilities should provide for the receipt of reprocessing waste. However, we believe that the demonstration facilities should be designed for and receive both high level reprocessing waste and spent fuel.

Along these same lines, section 4(c)(1) of the bill directs the Secretary to provide, on a priority basis, facilities suitable for providing a waste form that is resistant to the release of radionuclides. In keeping with the over-all research, development and demonstration scope of the bill, we read this provision as envisioning the use of a research, development and demonstration solidification facility, and not directing a larger scale undertaking. It might be helpful, however, if this point were clarified. Section 4 also prescribes dates for the operation of the two technology demonstration repository facilities in terms of the end of fiscal years 1987 and 1988.

These appear to be easily achievable. We would note, however, that -- if sites where substantial information already exists were chosen -- the schedule might well be expedited.

With respect to engineered barriers, which are also addressed in section 4, the position of the industry -- and DOE -- has been for some time and continues to be that the disposal of high level wastes must be viewed on an over-all systems basis. The required containment and isolation of the wastes are to be accomplished by the total performance of all the components of the system; not necessarily any single component. This reliance on a systems approach is completely consistent with the views that have been put forth by other authoritative groups, and is recognized in H.R. 1909.

In connection with the technology demonstration facilities proposed in the bill, it is provided that the engineered barriers -- one component of the over-all waste disposal system -- shall have a design life "at least as long as the time period needed for the health hazard of such wastes to become comparable to the health hazard of the uranium ore mined to generate such wastes." While we believe that, for the purposes to be accomplished by these facilities,this is a conservative -- but not necessarily unreasonable -- provision, we would urge that such a requirement not be construed as a standard to be met in connection with agency regulations applicable to a full-scale operating system.

As we have previously stated at some length in our Statement of Position submitted in the NRC Waste Confidence Rulemaking (which we would be pleased to make available for the Subcommittee's files) we believe that repository performance should be prescribed in terms of over-all system performance; and that a rational standard for the waste disposal system should be that people not be exposed to radiation levels -- as a result of system operation -- in excess of a fraction of the variations in natural background radiation. It might be useful to consider a design lifetime for engineered barriers in the technology demonstration activities to be tied more specifically to the period of fission product decay -- 300-500 years.

Finally, we note that the bill in sections 4(d) and 7 calls for DOE consultation with both state officials, from states in which any potential demonstration facility sites are located, and the heads of appropriate Federal agencies. We believe such consultation to be not only appropriate but vital to the success of the research, development and demonstration activities called for in the bill.

Turning to the last question, as to whether the emplacement of a minimum of 20 MT of waste in the proposed technology demonstration facilities would satisfy the requirements for demonstrating the closure of the fuel cycle, in our view it would -- or at least it should. Other segments of the back-end of the nuclear fuel cycle -- spent fuel reprocessing and high level waste solidification -- have already been demonstrated in this country and abroad. At Hanford the Commercial Nuclear Waste Vitrification Program successfully reprocessed a nominal quantity of commercial spent fuel and converted the high level wastes to solidified glass form.

With respect to the waste disposal segment, I have said earlier that we firmly believe the technology exists to enable us safely to accomplish this. The operation of the technology demonstration facilities as proposed would provide further substantial, concrete evidence to support this belief and thus provide the specific bases for concluding that nuclear fuel cycle closure has been demonstrated.

It is recognized that some states have adopted legislation directly relating to this question. Since their criteria for meeting requirements of demonstration are not clear to us, we cannot say whether our comments on this point reflect satisfaction of those criteria. We suspect, however that -- in some instances -- nothing short of the actual long-term operation of a full scale, licensed repository would satisfy the requirements. This interpretation is obviously unreasonable.

In concluding we would like to reiterate our support for an over-all, integrated waste management program culminating in the operation of a full-scale repository. In this regard, the technology demonstration projects provided for in H.R. 1909 would be a valuable program element. We stand ready to assist the Subcommittee in any way that we can.

We would be pleased to answer any questions.

Ms. Bouquard. We thank you, Mr. Snipes, for your excellent testimony, and we will certainly be in contact with you to take full opportunity of your knowledge, your ability, and your expertise.

Our next witness is Mr. David Berick. Your written testimony would also be included in the record if you should choose to summarize. You may proceed at this time.

Mr. Berick. I take that as a gentle hint.

Ms. Bouquard. No. We are wishing to accommodate you.

## STATEMENT OF DAVID BERICK, ENVIRONMENTAL POLICY CENTER, WASHINGTON, D.C.

Mr. Berick. I appreciate the opportunity to testify before the subcommittee today. I will try to summarize my remarks here.

I think it is important, first of all, to point out the importance of Congressman Goldwater's bill and the actions that the committee are taking, in addressing what I am going to call the "front end" of the Department of Energy's efforts to solve the permanent waste disposal problem; that is, the research and development process.

I think that the frustrations that people on both sides of the nuclear issue have with the Federal Government's actions or inactions on nuclear waste disposal can be linked directly to the ever-changing disruption and changing priorities that occur within the Department of Energy's programs.

I think that the proposals in H.R. 1909 head in the direction of addressing this confusion and rather rapid series of changes that occur. I think the most important contribution that the bill makes is the requirement in section 5 that a Comprehensive Program Management Plan be established and that it serve as a basis for annual budget allocations and program direction. As I will discuss later, I have some reservations about the limited scope (of this plan), but I think that it is important that we come to some understandings both within the Congress and within the Department of Energy and the other Federal agencies, as well as the State governments, as to what it is that the Department of Energy program is trying to achieve.

I seriously doubt, however, that the proposal for technology demonstration (in H.R. 1909) may, in fact, be one more of these disruptions and changes in DOE's programs, especially at a time of increasingly limited resources of the Department and that we may find these kinds of technology demonstration efforts counterproductive to the overall goals of the Department when faced with budget reductions and limited conditions of manpower.

Let me quickly turn to the three questions that the committee staff has proposed.

The first concerning DOE's waste program and focusing that program on permanent disposal: I don't really think the problem is the lack of focus of the program on permanent disposal. I think the DOE program is already focused on permanent disposal. The problem is focusing those DOE programs within the waste program on permanent disposal and getting an understanding of a more rational, methodical effort of what the goals are and what needs to be accomplished to attain the goals. This was recognized in the IRG process. It is certainly recognized in the support that the national plan has received. It is recognized in Congressman Goldwater's bill, and it is certainly recognized in Congressman Lundine's bill concerning the need to come to some very clear cut and direct agreements as to what the goals of the program are in a mission plan or a series of specific program steps to lend continuity in the budget process; with continuity in the program, those goals can be attained.

I think that, if we look at something like the waste isolation pilot project in New Mexico, you find perhaps a very good example of what happens when there are so many changes within the program. Because of actions by the Congress, actions by the previous administration, actions within the Department itself, one, after awhile, is not sure what the intent of the project is any more. Not only does that completely disrupt the actions within the Department, but the public—especially, the State of New Mexico—eventually believes that there is some kind of conspiracy to confuse and set it off track. The result is just increased public opposition to what the Department is trying to do, rather than gaining support for their effort.

In this regard, we have supported the work on the national waste plan and the complementary Earth science technical plan processes, and we have also supported the passage of comprehensive legislation which would establish in law a timetable and procedures for the development of a permanent licensed geologic repository.

The second reason why I think that a national plan process is important is that the waste program, and what capability the Department has, be done in conjunction with the actions of other agencies and responsibilities of other agencies. My fear is that the proposal laid out in H.R. 1909 is too limited and does not really bring in the responsibilities of those other agencies. Again, for example, going back to WIPP project, we have a continuing problem with the Bureau of Land Management and the need for land withdrawal and the disruptions in schedules and expectations for that program when one does not bring in the other agencies that are responsible for carrying out, even in this case, research demonstration programs.

With regard to the committee's first question, I think the most important thing that the committee can do is to encourage and lend support for those processes already underway within the Department to develop a national waste plan and those complimentary processes for a site selection plan and for an Earth science technical plan. I think that is what is really necessary to speed up these processes to actually get progress within the Department's program.

With regard to the second question which was the impact or the effectiveness of H.R. 1909 with regard to focusing the Department's program, a series of questions came to mind. I would like to run through them briefly.

I think the first problem is that, again, with limited resources, there is sort of a redundant function that is being set up here between the technology demonstrations and those programs already under way at the Department.

There is the Nevada Test Site where spent fuel has been emplaced, and the Near Surface Test Facility at Hanford where spent fuel and vitrified waste experiments are scheduled. An additional test facility was authorized by the Congress last year in the fiscal year 1981 Energy and Water Development Appropriations Act. As Dr. Witherspoon has pointed out, there are additional cooperative programs in Sweden. I think we have to look very carefully at what the impact of a technology demonstration would be on those existing waste test facilities and those test programs which are going to emplace high-level waste, and which are providing some very important information. I think that the potential for redundancy is even heightened by the fact that—as Dr. Witherspoon pointed—there is a need for this site specific information at each site that we would eventually try to develop as a repository. To some extent, while these individual demonstration facilities might add to a more general body of knowledge, I think there is some question as to how valid they would be in leading us to that next step of establishing a permanent repository or even, in the approach in Congressman Lundine's bill, of an intermediate scale facility.

Second, and along those same lines, is that the Earth science technical plan and some work being down to summarize the status of technology by DOE and Battelle indicate that a more methodical research approach is required and that there are some significant scientific uncertainties that remain. I think there are serious problems as to whether these technology demonstrations are occurring at the right time vis-a-vis those other uncertainties—those other research programs.

Third, I think there is an open question about the need for and the purpose to which a demonstration project would be useful. I think there is a fundamental issue, even within the context of this bill, of a 1,000-year problem—these engineered barrier designs—being demonstrated in a 20-year period. I think, as members of the panel have already pointed out, there are a series of things and a level of proof that are going to be required, perhaps, by State energy commissions, by public utility commissions, by the public at large. I think there is a very serious question as to the validity, again, of attempting to demonstrate something to the public or to these other bodies which requires perhaps a 1,000-year solution or, in the minds of some people, a 10,000- or 100,000-year solution in a condensed 20-year demonstration program.

Fourth, I think, the design parameters of the repository for the demonstration project are going to raise a lot of questions with a number of people. Partly because uranium ore is not in itself an innocuous material, and work that is being done at Oak Ridge for EPA to establish drinking water standards for uranium and the new information is based on the national uranium resource evaluation program, which is a national program to look for uranium sources in the United States, is finding that there are significantly elevated levels of uranium in drinking water supplies all over the country. These naturally occurring ore bodies do have a rather pronounced and immediate public health implication so that they, in and of themselves, are not necessarily safe neutral levels to set standards.

For example, the preliminary estimates of the new Oak Ridge data are that between 250 and 2,500 drinking water supplies in the

U.S. would not meet the existing 10 picocurie level—for uranium—and, if that was dropped to 5 picocuries, which the EPA is considering doing, both on radiotoxicity and chemical toxicity levels, somewhere between 2,000 and 5,000 drinking water supplies would not meet that level. Again that is from the naturally occurring uranium ore.

Along those same lines, EPA as part of its own efforts to establish standards for geological repositories looked at the uranium ore issue and did an estimate—that I am just going to throw out for discussion—that the potential risk to the U.S. population from a generic ore body was somewhere between 100 and 1,000 cancers per year, largely due to radon. The point I am trying to make is that the uranium ore standard is going to raise some serious questions with people.

I think what is required is legislation which establishes specific requirements for a research and development plan similar to the comprehensive R. & D. in section 5 of H.R. 1909 but broader in scope, but I believe the problem can't be left there—that we have to go and clearly define a process for site selection, eligibility requirements for sites, and that we can't limit ourselves just to this research program.

Finally, with regard to the third question about the closure of the fuel cycle, I just want to make a couple general remarks. I do not think the closure of the fuel cycle is an especially helpful objective for the Department of Energy or the Federal waste program. Given the fact that we have not had a fuel cycle in the traditional sense and that, even with the programs that are being proposed now for demonstration or reprocessing in the breeder, a commercial fuel cycle would be decades away and might not in and of itself be a useful objective. Nor would it be useful in light of the fact that the defense waste comprises a very significant, a very controversial part of the Department of Energy's waste disposal responsibilities, and that would really fall outside of the entire fuel cycle issue.

Thank you.

[The prepared statement of Mr. Berick follows:]

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# Testimony Before the Subcommittee on Energy Research and Production of the Committee on Science and Technology

Concerning H.R. 1909
"Nuclear Waste Research, Development and Demonstration Act of 1981"

By
David Berick, Washington Representative
Environmental Policy Center
February 26, 1981

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Thank you for the opportunity to testify on H.R. 1909, "The Nuclear Waste Research, Development and Demonstration Act of 1981". I would like to make a few general remarks concerning the proposed legislation, especially as it compares to similar legislation (H.R. 7418) reported by the Committee last year, and then address the series of questions posed by the Committee staff.

First of all, I think that it is especially important that the bill and the Committee address what for our purposes I will call the "front end" of the waste repository development cycle. The frustration that people on both sides of the nuclear issue feel concerning the Federal Government's actions and inactions on waste disposal can be linked directly to the numerous changes in program priorities, goals, research efforts, and in the purpose and mission of specific waste projects. The most notable example is the Waste Isolation Pilot Plant in New Mexico, which has been subjected to changes in its intended purpose, budget, and role in the overall federal waste program. To the extent that the entire research and site selection process can be more formally established, we can substitute continuity for chaos. Criticism of those programs can serve a constructive role rather than the entirely adversarial relationships which prevail now.

I think that some of the proposals in H.R. 1909 head in this direction, notably the requirement in Section 5 that a "Comprehensive Program Management Plan" be established and that it serve as a basis for annual budget allocations and program direction. As I will discuss later, I believe that the proposed plan is too limited in scope, but it represents a recognition of the need for an orderly program planning process which is only now evolving. In this regard, I think that H.R. 1909 with its emphasis on research and technology developments is a significant improvement over its predecessor, H.R. 7418. Rather than a series of "free floating" demonstration repositories, H.R. 1909 makes a much more constructive proposal to structure, and in the words of Staff questions, to focus the waste disposal research programs at DOE. I do, however, have a number of reservations about whether the reallocation of DOE's increasingly limited resources to the proposed technology demonstration will be beneficial. In fact, such a drastic redirection of DOE's program may well be counterproductive as DOE is required to devote is efforts to the completion of the two projects rather than longer term objectives.

Question 1 concerning the need to focus DOE's waste program on permanent disposal; I would like to approach this question in a slightly different way. I do not think that there is a problem in keeping DOE, itself, focused on permanent disposal of radioactive waste. Rather, the real question implicit in your original query is how do we make progress on permanent disposal.

DOE is focused on permanent disposal. With the exception of efforts begun under the Carter Administration to make DOE responsible for the management of spent fuel and legislative actions in the 96th Congress aimed at establishing a long-term storage policy, DOE has been expending increasing millions of dollars on permanent disposal. The Environmental Policy Center, for one, has supported this increased effort and has testified before both House and Senate Appropriations Committees in each of the last three years for increased funding and program expansion for waste disposal programs.

As implied by the Committee's question, however, increased budgets do not necessarily satisfy the need for progress. Let us take this in two parts. The first is that the need for progress is essentially a political one. Indeed, in its filings with the NRC on the Waste Confidence Proceeding, the Utility Waste Management Group pointed out that there is no need for a repository at any particular time and spent fuel could be stored for an indefinite period. Without defending or criticizing such a position, it is important to point out that much of the push for waste disposal stems from outside political pressures, especially constraints, real or imagined, on nuclear development. Congressman Goldwater pointed this out to some extent in his remarks accompanying the introduction of this bill. If we are to have real progress in this area, we must measure it and our expectations against a more independent bench mark than political expediency.

This is one of the reasons the Environmental Policy Center endorsed the Interagency Review Group on Nuclear Waste Management recommendations for a comprehensive national waste plan and why we have urged completion of complementary technical planning efforts such as the Earth Science Technical Plan. This is also the reason why the Center has supported passage of comprehensive legislation aimed at establishing in law a timetable and procedures for the development of permanent, licensed geologic disposal repositories. I might also add that this same concern has encouraged our opposition to proposals to create various DOE storage programs.

The second reason why progress in nuclear waste disposal cannot be left to the size or allocation of DOE's annual budget is that the federal permanent disposal effort truly transcends the Department's programs, and should. Despite all of the criticism surrounding the Interagency Review Group, I think that there are a number of very sound lessons to be learned, not the least of which is that DOE does not and should not operate in a vacuum. Actions by the Department of Interior, Department of Transportation, EPA and NRC are important not only to the "success" of DOE's efforts in a technical & peer review sense, but in terms of public acceptance and institutional credibility as well. As I will discuss below, demonstration of a technology means different things to different parts of society. Without independent review, both the technical and institutional goals of any demonstration of progress is suspect and perhaps counterproductive.

If progress is to be made on high-level waste disposal, I think that all sides must accept a series of formal and participatory planning processes building on the national waste plan and Earth Science Technical Plan efforts and extending to individual Federal/State site investigation and development plans. These need not be perceived as more in "a seemingly endless series of studies, reviews, and evaluations..." as described in Congressman's Goldwater's remarks. Rather, they are essential processes of agreement on goals and objectives of the Federal waste disposal program.

Where Federal nuclear waste programs have run into trouble is in those situations, such as WIPP, where there has been a lack of continuity, justification, and explanation of the Federal game plan. Lack of continuity, both in the public's eyes and within the agency itself, is a most serious hazard to progress on waste, whether it results from action by Congress, a change of administration at 1600 Pennsylvania Avenue, the budget process, or within the agencies themselves. I think the most important step which can be taken by this Committee on nuclear waste management is to allow and encourage ongoing DOE and interagency research and repository development planning efforts.

Question 2 concerning the impact of H.R. 1909: The Nuclear Waste Research, Development and Demonstration Act of 1981 does not, in my opinion, provide the necessary impetus to assure the orderly and accountable pursuit of permanent disposal by DOE.

First, there are a number of questions about the feasibility of the type of technology demonstration proposed in the bill, especially in the absence of an overall research and development plan . The basic function of the proposed facilities appears to be redundant in light of DOE's in situ test program on the one hand and both DOE's and NRC's commitment to at-depth site characterization at potential repository sites.

DOE has test facilities in operation at the Nevada Test Site and at the Near-Surface Test Facility at Hanford. Spent fuel has already been emplaced at NTS and experiments with emplacement of vitrified wastes and spent fuel are scheduled for Hanford. An additional test facility for salt was approved by Congress last year in the FY 1981 Energy and Water Development Appropriations Act. These research facilities, along with additional research programs such as the one at Avery Island, Louisiana in salt and cooperative programs with Sweden in granite, are providing important new information on geologic disposal and can be expected to continue to do so.

It is not at all clear that the demonstration facilities proposed in the bill would provide significantly different data than being developed at such test facilities, except on site specific qualities. Since these will be unique to a significant extent for each site, and the necessity for extensive site specific characterization is well accepted, the proposed facilities may add to the body of general information, but may well do little to aid in the development and technical and social approval of a permanent repository.

Second, the proposed demonstration facilities appear to be out of phase with ongoing research work such as the Earth Science Technical Plan and DOE/Battelle report on the "Status of Technology for Isolating High-Level Radioactive Wastes in Geologic Repositories". (DOE/TIC 11207, October 1980) These assessments along with others argue for a more methodical research effort and deferral of technology demonstration.

In fact, the most serious problem with the H.R. 1909 technology demonstration proposal is that it will, in all likelihood, result in one of the many sudden redirections which have befallen the federal waste program.

Enactment of H.R. 1909 could result in a serious disruption of these ongoing research and planning efforts, both in terms of program direction and the allocation of increasingly scarce federal resources, as DOE is forced to devote much of its waste program effort to technology demonstration. H.R. 1909 may well have the opposite of the desired effect by derailing DOE's waste program rather than increasing its efficiency and productivity.

Third, there is an open question, to which I alluded earlier, as to what purpose such a demonstration would be aimed. I suggest that while there may be a particular "standard of proof" for the general public which may be achieved by the proposed demonstration by the Department of Energy, this standard will be entirely inadequate to residents of potential host states or to intervenors in licensing hearings or to the courts. I also suggest that there is a fundamentally different standard of proof required of the Department of Energy than there might be for an independent or private effort to demonstrate a particular technology; the result of the lack of credibility of the DOE on this issue and because the public is expected to believe that this feat (the successful demonstration) can be replicated by unwieldy government agencies.

Fourth, the design parameters of the repository, including the use of engineered barriers and the establishment of a performance standard based on the hazard of uranium ore, raises some serious questions about the "adequacy" of the demonstration of protection of public health and safety. Uranium ore is fairly toxic material, both as an ore body and as a mined product, because of the toxicity of uranium and other components such as radium. Radium has a radiotoxicity equivalent to uranium, and an even higher chemical toxicity; something on the order of seven times greater.

EPA's interim guidance for uranium in drinking water is 10 picocuries/liter. Recent studies completed by Oak Ridge for EPA, using a variety of new data generated as part of the National Uranium Resource Evaluation Program, indicates that somewhere between 250 and 2,500 drinking water supplies in the U.S. would not meet this level and between 2,000 and 5,000 would not meet 5 picocuries/liter. In short, uranium ore bodies constitute a health risk.

The suggestion that uranium ore bodies might be an appropriate "natural" measure of risk to the public has usually been suggested as a risk for the entire uranium fuel cycle, i.e., the risk to utilizing the ore should not exceed the risk to the public from its natural state. As suggested by the EPA drinking water study, this risk is not necessarily small. A recent EPA analysis of the public risk from such ore bodies, as part of EPA'S own effort to set standards for geologic repositories, indicated a potential risk to the U.S. population from a generic ore body of 100 to 1,000 cancers per year largely due to radon. (EPA-520/3-80-009, October 1980, "Population Risk from Uranium Ore Bodies"). Clearly, uranium should not be used as a standard.

Additional questions arise concerning the anticipated demonstration of containment by engineered barriers for a roughly 1,000 year period. Not only have serious questions been raised about the adequacy of vitrified waste forms, which I discussed to some degree in my testimony last year on H.R. 7418, but there is a lot of doubt that general public acceptance of this "thousand year" technology could be gained in a twenty year demonstration. What can be demonstrated, perhaps, is the validity and accuracy of DOE's design methodology, modeling, and quality assurance. This can best be done, in my view, through a carefully structured and independently reviewed research effort aimed at the establishment of permanent repository development rather than through the proposed technology demonstrations.

What is required is legislation which establishes specific requirements for a research and development plan, similar to the comprehensive R& D plan required in Section 5 of H.R. 1909, but broader in scope and encompassing interagency agreements. In addition, a clearly defined process, including selection and eligibility criteria, is required for DOE's site selection process. To the extent that DOE has been looking at too few sites, in too few media, it has left itself open to attack for putting too many eggs in too few baskets. It has also resulted in increased local opposition as individual sites or regions are perceived to be the principal target for DOE when in many situations this is not the case.

Finally, relationsips between state and local governments and the DOE and other federal agencies involved in waste disposal activities cannot be left to vague assurances that DOE will consult and coordinate with state officials. To do so, especially in anticipation of the inevitable program and policy changes, is to ignore the history of federal/state relationships in this area. States must be given a clear cut opportunity to participate in DOE's waste program decisions,and DOE itself must be constrained in terms of those activities for which it must seek concurrence from the affected state. Failure to lay out the ground rules in advance can only inspire states to exploit opportunities to halt waste projects when they arise.

Question 3 concerning the value of technology demonstration to prove closure of the fuel cycle; First, I would point out that there has never really been a commercial fuel cycle in the classic sense of reprocessing and plutonium recycling. There continues to be great uncertainty concorning the public policy and economic feasibility of reprocessing and breeder reactors. Even assuming a federal demonstration at the Barnwell reprocessing plant and completion of a breeder, commercial development of either of these technologies would be decades away. In short, I do not think that it is realistic to establish closure of the commercial fuel cycle as a realistic goal for nuclear waste programs, especially near-term.

A second reason why fuel-cycle closure should not be a guiding objective is that it is an irrelevant consideration for defense wastes which comprise a significant and politically controversial component of DOE's nuclear waste responsibilities. The lack of "closure" and the double standard that has prevailed concerning defense wastes can be expected to continue and cloud whatever ray of hope devlops from the proposed disposal demonstration. Furthermore, if there is little willingness to dispose of wastes, either spent fuel or defense wastes, a demonstration is at best a hollow gesture.

Thirdly, questions raised by the courts and addressed in the NRC's waste confidence proceeding deal not only with the validity of the NRC's determination that a "reasonable assurance" exists that wastes generated by nuclear fuel cycle facilities can be managed, but with the larger question of what is the burden of proof. What level of progress or what level of uncertainty either confirms or denies a determination of reasonable assurance? In this context, a demonstration may be a way of confirming the validity of DOE's methodology and models. Emplacement of such a minimal amount of waste in a facility designed to demonstrate that capability would not confirm or deny that a reasonable assurance existed for permanent isolation of the types and volumes of radioactive wastes on hand or expected to be generated. It might give us more or less confidence in our ability to "close" the cycle, but it would not demonstrate it.

Thank you.

Ms. BOUQUARD. Thank you very much, Mr. Berick. We certainly do appreciate your excellent testimony and your input into our hearings this morning.

Before we go ahead with the questioning of our panel, which we are certainly looking forward to, I would like to recognize the gentleman from New York, the Honorable Stan Lundine, who is also a member—a very valuable member—of this subcommittee. Congressman Lundine this week has entered his nuclear waste management bill, H.R. 1993.

Mr. Lundine, we would like to hear from you at this time—your remarks in reference to your legislation.

Mr. LUNDINE. Thank you, Madam Chairwoman.

I think I will just ask unanimous consent that those remarks be placed in the record following the remarks of any others who made opening statements so that we can get right on with the questions, and I do ask such unanimous consent.

Ms. BOUQUARD. Without objection, so ordered.

We will go ahead with our panel. Dr. Witherspoon, I notice that, in your testimony, you rejected the need of placing actual waste in demonstration repositories. You felt this was not necessary for technical need; but, looking a little bit further, do you think placement of waste in repositories is really more legitimate to demonstrate to the public the confidence that they would like to have that we are indeed capable of disposing of our waste in a safe and environmentally accepted manner?

Dr. WITHERSPOON. I realize that these political problems probably outweigh the technical view that I have portrayed here, but I would reiterate a concern that I have that, as one proceeds to try to convey to the public through that kind of a demonstration, that waste can, indeed, be placed underground. If one does it in the proposed test facilities as presented here in H.R. 1909, will that be sufficient? That is a question that arises in my mind, and that is why I pointed to what may be a question that arises later having demonstrated that it can be done in a test facility as called for in H.R. 1909. Will the public then say—but you have not really done that in the real repository—and what does one do at that point in time?

So I fear I can speak to the technical problems, but I have difficulty giving you a good answer to all of the political implications.

Mrs. BOUQUARD. Would the criteria that you outlined earlier in your testimony regarding the geologic media rule out repositories in salt?

Dr. WITHERSPOON. May I have that question again, please.

Mrs. BOUQUARD. You outlined in your criteria regarding the geologic media on page 2, in the middle of the second paragraph: "A dense material with low seepage rates [permeability]." Would this in your estimate rule out salt repositories?

Dr. WITHERSPOON. No. That was not my intention.

Mrs. BOUQUARD. What is your preferred media for repository?

Dr. WITHERSPOON. My work has been in granite or one could call it "granitee" types of rock. I must say that I find them to be very suitable because they are strong. They can resist heat, and I believe they can be found to be essentially as impermeable as the salt types of media.

So my preferred media would be a granite, meaning of the granite family of rocks—hard, crystalline rocks.

Mrs. BOUQUARD. Thank you very much.

I am going to try to observe the 5-minute rule the best I can this morning.

I'll go ahead with Mr. Snipes.

How dependent is closing the fuel cycle; that is, disposing of high-level nuclear waste, to the utilities in proceeding with the ordering of nuclear power plants? Do you see this going hand in hand, or do you have other priorities for reinitiating procurement of plants?

Mr. SNIPES. We believe that a solution to the waste management question is vital from the standpoint of, first, public perception. As we have stated in our testimony, we believe a date certain for a full-scale operational repository is not critical in terms of safety; that is, protection of public health. Safety in that technology is fully in hand for long periods of time for the waste that we generate. Second, it is of course an economic problem for utilities in terms of adequate storage capacity, but we view the waste management question as essentially a question of public perception.

Mrs. BOUQUARD. How would you differentiate between the priorities of closing the fuel cycle—that is the need to start emplacement of high-level waste now—and going ahead with our reprocessing program?

Mr. SNIPES. Could you clarify your question, Madam Chairman?

Mrs. BOUQUARD. Refering back to earlier testimony from Secretary Edwards, he said that he felt we needed to go ahead with our repository programs, the breeder program, and reprocessing and that all three of these technologies must be operating hand in hand.

So what is your comment on this?

Mr. SNIPES. As a representative of the utility nuclear waste management group, obviously, in my day-to-day work, I tend to see the waste management question as the foremost question confronting the ultimate viability of nuclear power from a public perception standpoint.

I cannot make a statement that industrywide—this waste management question stacked up against some of the other questions which are confronting the industry—that this is most important. In my view, it is the most important.

Mrs. **Bouquard**. Thank you very much.

One question, Mr. Berick. Are there any specific environmental considerations that you feel should be incorporated into this legislation?

Mr. **Berick**. Well, I think that the thrust of the demonstration repositories needs to be clarified. We have to understand whether we are looking at a test facility, which is a temporary minimal impact kind of enterprise, or we are looking at something more along the lines of a repository where significant quantities of waste are going to be put.

I think that there is some confusion in my mind over exactly how large an undertaking these demonstration facilities would be. I would be reluctant to exclude these kinds of efforts from NEPA or, in some cases, potentially, from licensing, unless there is some understanding of exactly what kind of project we are talking about. I think that really needs to be clarified.

Mrs. **Bouquard**. This is just a test facility.

Mr. **Berick**. It is a test facility, but one is looking at potentially——

Mrs. **Bouquard**. It is a demonstration.

Mr. **Berick** [continuing]. At twenty years of emplacement of different kinds of waste with surface facility. I think that, in my own mind, I am not clear as to what the impact would be and, as far as the environmental concern that needs to be addressed, we would need some kind of assessment process, probably under NEPA, that would look at what the impact would be—that we wouldn't automatically exclude these kinds of facilities and their potential impacts, which are still uncertain because we are not really sure of what we are undertaking here.

Mrs. **Bouquard**. This is still an R. & D. facility of limited size and scope.

Mr. **Berick**. Well, you say it is limited, and the people in whose back yard it is going to be put might not think it is limited.

The question really comes down to whether we impose some kind of interim step where there is a forum for discussing what the impacts will be and that those be addressed.

For example, when the Department of Energy is now going out and drilling holes in its salt domes or its potential sites, it is doing an environmental assessment. It is making a determination of the impacts that it incurs by that process. I think that step needs to be included.

Mrs. **Bouquard**. Thank you very much.

Mr. Lujan?

Mr. **Lujan**. Madam Chairman, Mr. Goldwater has to catch an airplane, so why don't you recognize him.

Mrs. **Bouquard**. We will defer to Mr. Goldwater. Please proceed.

Mr. **Goldwater**. Thank you, Madam Chairman.

Gentlemen, I appreciate this discussion today. I think oftentimes we lose perspective of what it is we are trying to do.

As I understand the magnitude of this problem is that, we can assume that we may have anywhere from 160, to perhaps 180, plants producing waste by the year 2000. We are talking about a waste problem that, if you put it on top of a football field, it would be no more than about 5 feet high. We are not talking about large quantities of material that we have to deal with.

The purpose of my efforts in this, and I think it is shared by many members of the Congress, is that we have been studying this issue to death in essence and that we are not really getting down to demonstrating the capability to the satisfaction of the public that, in fact, this problem is manageable.

Dr. Witherspoon, you are a scientist. Your profession is to understand the Earth. Without that kind of expertise, we would not have the knowledge in order to proceed.

I have to deal with the political reality of this problem. My concern is that the mere studies, in and of themselves, are not going to satisfy the public that we can manage nuclear waste. That we have to take it out of the laboratory, take it off the paper, and actually see if what all your work that you have been doing results in the ability to satisfy the minds of the public.

Therefore, this bill and similar bills prepared by members of this committee all have a bottom line to accelerate this process and take it out of the laboratory, off the paper, and actually build something to demonstrate the capability.

You bring up the question of whether this accelerated process might confuse or disrupt the ongoing Department of Energy's waste program. It certainly is not our intention to do that, of course, but to give it some direction, and that is actually to do something instead of just to continue the study.

Do you disagree with this analysis or the objective of this political approach? Are we getting the cart before the horse? Do we, in fact, not know enough? Do we truly have to continue to study this thing on and on and on, or do we know enough to actually put a hole in the ground and put this material down and monitor it in a real life environment?

Dr. **Witherspoon.** Let me give you an example of the basalt project in Hanford, Wash.

There is a real concern that the basalt flow—it is a section of rock about 200 feet thick—about 3,500 feet deep where the BWIP people are now considering placing a repository.

Above that 200-foot layer and beneath that 200-foot layer are what I would call leakage paths. They exist.

The question then becomes how can one be sure placing a repository in the center of the 200 foot layer that the material would stay there.

That depends upon the vertical conductivity, and it can't be measured accurately at the present time with the present technology. It can't be measured in boreholes or with rock samples or any method that one can devise. So I and others have been encouraging the BWIP program to get underground at a depth of 3,500 feet and place in there a method that we have perfected in Stripa and measure that critical quantity.

Mr. **Goldwater.** Why can't we do that in parallel though?

Dr. **Witherspoon.** You could.

Mr. **Goldwater.** In fact, the facility at Hanford—I understand they already have a hole bored into the basalt?

Dr. **Witherspoon.** You mean the near surface test facility?

**Mr. Goldwater.** I can understand your concern but I would like to punch holes in the salt and put our 40 logs in place, have them retrievable, and monitored. In addition to monitoring the logs we could also monitor the geology or whatever else you believe should be monitored above and below the logs to actually see what the impact would be.

It seems to me you could put this thing in place and watch it carefully.

**Dr. Witherspoon.** I have no argument with that at all. That will satisfy my scientific concerns, and it will also take care, I hope, of this public concern that you are trying to address in this bill. Both can go along in parallel.

**Mr. Goldwater.** Mr. Berick?

**Mr. Berick.** I think we are talking about two things. I think one thing we are talking about is a political demonstration—something that will convince those people who are objecting to nuclear development because the waste problem is not being solved; that, yes, the problem has been solved.

I think one of the things we have to look at—if we are looking at a political demonstration—is the political context. What you are going to propose here is for the Department of Energy, that doesn't have credibility with those people whom you want to convince, to go out and demonstrate something and declare it a success.

I think one has to look at the downside of that kind of demonstration, especially if it is aimed at political ends because it will be more of the same. It will be more of what we are already criticizing DOE for doing, which is rushing ahead, putting waste in the ground before they really know what is going on, and that is what we have seen in Lyons, Kans.; we have seen it in opposition to WIPP.

As a political demonstration, one has to look at that entity that one expects to have credibility in declaring a demonstration a success. I don't think that can be separated.

**Mr. Goldwater.** But the project at Lyons, as I understand, was an experiment.

**Mr. Berick.** Excuse me. That is sort of my point, which is we had an experiment that may well have been successful. That did not impress upon anyone that waste could be emplaced in a salt formation as has been argued, or then Lyons should, in and of itself, demonstrate disposal. We should not be going through this exercise.

The problem is that the agency and those people responsible for the experiment did not have the credibility to convince anybody that what they had done was successful. That really is exactly my point.

**Mr. Goldwater.** I would not categorize this as purely a political action. We have had testimony here and have seen stacks of paper of research and studies that had been done that go back—I don't know how long—twenty years?—or even longer. We have a real time problem here that the utilities have to deal with. As a politician, I have to do deal with it also and the public is greatly disturbed about an apparent lack of solution.

As long as you continue to study something, you never satisfy those needs. Those are real needs. They are not imaginary; they are not fantasies. They are real needs. We have waste in spent-fuel storage all over this country. We have military waste sitting in cannisters that is piling up.

In Congressman Lundine's area of New York, you have a real waste problem.

The intent here is to move this forward. If we go with the Department of Energy's schedule, you are looking after the year 2000. In the meantime, this problem still exists with the utilities, the politicians, for States in themselves and their current needs for electrical energy.

By continuing to study and by dragging this out, we are not solving the local problems that we have to face. That is the reality with the real world. It seems to me by proceeding with a somewhat accelerated demonstration—and I think 1986–87 isn't all that much of an acceleration—parallel with the longer range work that we are doing at various sites around this country and in cooperation with other countries, we can accomplish both the political and technical objectives.

Until we put something in the ground, we will not prove all the theories and all the work that Dr. Witherspoon has been doing for years and years. I think that is the thrust. I don't think we should lose sight of that.

One other question I wanted to ask, and I think it was Dr. Witherspoon who was talking about the inability to really prove the 1,000-year performance inside of 20 years, but isn't it true that this is being done today, that by increasing temperatures, you can accelerate testing? In fact, I believe at Sandia, Dr. Molecke and Dr. Braithwaite have, in fact, been doing this.

Mr. **Berick**. I really prefer to refer part of that question to Dr. Witherspoon.

Again, I think you have to look at two problems. One is a technical problem. Yes, by doing those things you can confirm that the models you are using are sufficiently valid and accurate that, yes, you can extrapolate out to a 1,000 years. That does not need to be done in a demonstration facility.

The other side is, again, that very real political credibility issue which I raised, which is—is the public or are large sections of the public that are especially vocal about this going to believe you in a very commonsense context that, yes, this is going to stay in the ground for a thousand years or even the 10,000 or the 100,000 years that some sectors of the public believe, when one is only doing it in 20 years. I think this is a very serious commonsense credibility issue that needs to be overcome.

Mr. **Goldwater**. Mr. Snipes, do you have any comments on this issue?

Mr. **Snipes**. Well, I would point out that we can't say with any certainty that a demonstration facility of the type you propose would satisfy 99.99 percent of the population that we would be solving this problem.

When the choice comes down to additional studies or doing something concrete, which I think is the point we have reached, I think commonsense says to go out and do something—put something in the ground.

Aside from the public perception, the benefits of a program such as this, which I think I have tended to emphasize thus far, we do believe, and have said for some time in other forums that we need to get scientific data for the ultimate engineering design of the full-scale repository. We do believe that the information that would be developed by a demonstration facility at that depth, such as proposed in H.R. 1909, would serve us well in that particular respect.

Dr. Lieberman may be able to elaborate further, but I do emphasize that, while we believe public perception benefits from this program are real, that is not the only reason for doing this. We need to get confirmatory data for the final engineering designs of a full-scale facility.

Mr. **Goldwater.** Dr. Lieberman?

Dr. **Lieberman.** I would like to emphasize a point you made, Mr. Goldwater. Indeed, these studies do represent an opportunity to do this in parallel which would satisfy, I think, in a large measure. It seems to me the public would be much better served by, instead of looking at piles of paper, looking at something in the ground; but, at the same time, I think we would have to recognize from a technical standpoint—if I understood Dr. Witherspoon correctly, he also made this point—that, at the same time, you are getting that site—specific information that will help you validate the models—the chemical information, the thermal information—that provides the validation of what we already know, and we are convinced that we can do this and gives you the site specific information that you can use as the basis for—as Mr. Snipes has pointed out—these engineering designs of an actual repository.

It seems to me, unless or until we do that, everything will be on paper. We have not proven, to the extent that we think we can prove, that, indeed, this is a completely viable approach. It seems to me it is essential that we can on with that.

Mr. **Goldwater.** Thank you

Mrs. **Bouquard.** Thank you very much, Mr. Goldwater.

Mr. Lundine?

Mr. **Lundine.** I apologize for being late, but I read the testimony that I did not hear.

I found it all interesting, and I think there is a common agreement on some points, at least, that I consider very important.

All of you have suggested in one way or another that this country needs a definite plan for nuclear waste and that we need to go about it in some way both demonstrating for public perception, but also developing a definite plan in which the public can have confidence that we are doing more than just studying, and I agree certainly with that.

I assume that all of you have reviewed the Department of Energy's draft of a national plan for radioactive waste management. In fact, Mr. Berick commented a little bit on its vagueness and that he thought a more methodical effort needed to be done.

Would any of you comment further on the DOE plan—a plan that has just been issued in draft.

Dr. **Witherspoon.** I am not sure I understand what you are referring to.

Mr. **Lundine**. I am not sure if I can give you the date, but very recently the Department of Energy has published a draft national plan for radioactive waste management.

Dr. **Witherspoon**. I am sorry. I have not seen that.

Mr. **Berick**. As you know, Congressman, the national plan process is something that got started by President Carter's announcement, almost a year ago, articulating a specific Federal waste policy—a comprehensive policy.

One of the things requested by the President was a national plan, which for the first time would attempt to lay out what the Federal objectives were going to be for not only the Department of Energy, but for other agencies involved in the solution of not just a permanent disposable problem, which is the subject here, but a variety of waste problems that are facing us.

I think what is important to say is that we are now on draft 4. The drafting process in and of itself has been an important exercise, and a new exercise for the Department.

I think what we really need to do is look at the need for an ongoing plan that is going to lend continuity to the budget process, to the Department's decisions, to the incoming and future administrations, so that we don't end up changing what the agenda is and changing the function of this program or that program every 6 months or 18 months.

Mr. **Lundine**. I would like to address a question to Mr. Snipes, particularly; but, if the others of you would like to comment, you are certainly welcome to do so.

Do you agree that the disposal of spent nuclear fuel and waste which are generated by the private sector are essentially financially a utility or a private sector responsibility?

Mr. **Snipes**. The question as I understand it—does the utility industry believe that it should be responsible for the cost of disposal of its own waste. I think the answer to that is simply yes.

Mr. **Lundine**. Second—any of you who would care to comment on this—would you support payments to States that have located within their borders, whether they are research and development, retrievable or permanent repositories, in other words, in lieu of tax payments or some payment calculated to compensate them for what is perceived to be the burden of having repositories located——

Mr. **Snipes**. Mr. Lundine, we would support such payments to the host State of a full scale repository. I think the question is somewhat less clear with respect to a demonstration facility where the use of that particular site of land potentially could be of short-term duration.

Mr. **Lundine**. They may not look at it that way, though.

Particularly, it seems to me, we have all talked about going in parallel today but, unless they can see that at the same time there is progress on a permanent licensed repository, it seems to me they may have the suspicion—I can assure you they would if it were located in western New York, but that is an aside—that temporary won't be all that temporary and that the burdens of just typical Government services and the impact upon the area may not be really short-lived.

Mr. **Snipes**. Let me restate that I think the question with respect to the full-scale permanent repository is clear that such payments in lieu of taxes should be made. I am simply saying for the demonstration facility the situation is in my mind unclear, not necessarily that we would take the position today that payments should not be made or should be made.

Mr. **Lundine**. Madam Chairwoman, I have additional questions, but I don't want to exceed my time.

Mrs. **Bouquard**. Would you like to submit statements to our witnesses to be included in the record?

Mr. **Lundine**. I would like to ask one very pointed additional question but, if Mr. Lujan would rather I wait until after he is through——

Mr. **Lujan**. Go ahead.

Mrs. **Bouquard**. Please go ahead.

Mr. **Lundine**. A simple question, but perhaps it won't be a simple answer, what do you think that our Nation's posture on nuclear reprocessing ought to be and why?

Any one of you or all of you.

Mr. **Berick**. I think we are all going to have different postures. Our position, as it has been with the spent fuel management issue itself, is that it really just is a private sector responsibility.

We did support President Carter's inquiry into the proliferation consequences of reprocessing.

We would hope that those kinds of reviews and public policy concerns could be kept uppermost in the incoming administration, but I think that we believe that there needs to be a decision about whether it is going to be a private sector responsibility or a public sector responsibility. We are talking about commercial fuel for commercial powerplants. It should be a private sector responsibility, and the Federal Government should not be involved.

Mr. **Lundine**. In other words, you don't object to reprocessing per se, given the fact that the antiproliferation effort turned out to be like a guy marching down the street trying to lead a parade and finding out that there weren't any bands behind him. [Laughter.]

You don't object to reprocessing, but you would be very concerned under what financial arrangements and the like were to be realized or raised?

Mr. **Berick**. There might not have been a lot of bands, but I think everybody heard the music. [Laughter.]

I think the exercise really did heighten an international awareness of the problem, and I would hope that those kinds of policies would continue to be argued for within the Congress, and the administration would be cognizant of those.

I think that that is separate from the fact that we have to look at this as a commercial technology; and, within that context, there are things like NRC licensing, and the NRC review of the environmental impacts under GESMO, the environmental statement on mixed oxide fuels, those things should be included. If it is going to be commercial, it should be treated as a commercial technology. We should not start writing in loopholes in that process. It should be one or the other.

Mr. **Lundine**. Would either of the other witnesses care to comment?

Mr. **Snipes**. Mr. Lundine, I would like to make two comments. First, the utility industry in general has, in the past, supported and continued to support commercial fuel reprocessing and deployment of the breeder reactor. We feel the benefits of the Nation in terms of a vastly expanded energy resources which would result therefrom would be extremely valuable.

The second comment, I would have to say that, in my mind, a precondition for reentry into the reprocessing business by the commerical sector has got to be some expectation of stability in the political and regulatory area.

Mr. **Lundine**. On that point and just one follow-up, don't you think it would be helpful if both Congress and the administration would unequivocally express themselves on this issue, rather than really just allowing for a statement to be made by an administration that conceivably could change in 4 years.

Mr. **Snipes**. Yes, sir.

Mr. **Lundine**. I thank you, and I thank all of my colleagues here. Thank you.

Mrs. **Bouquard**. Mr. Lujan?

Mr. **Lujan**. Thank you, Madam Chairman.

Mr. Lundine, let me ask you, the statement that you are saying ought to be made by both the administration and Congress is whether the reprocessing ought to be done by private industry or should the question be should we go on to reprocessing? I didn't quite understand the question.

Mr. **Lundine**. It is my view that a definite policy ought to be stated and agreed on, frankly, between the administration and the majority of those in Congress and that the basic terms or principles on which it would proceed ought to be included; in other words, a general statement. We just heard a little bit of difference expressed by two witnesses who said that they didn't necessarily object or, in the other case, that they favor reprocessing.

It would seem to me useful to settle the question and to provide a more certain regulatory environment that both Congress and the administration in some way establish a policy.

Mr. **Lujan**. As to processing itself?

Mr. **Lundine**. As to processing; yes.

Mr. **Lujan**. Private enterprise versus Government?

Mr. **Lundine**. Well, both. I mean, one of the essential elements of a reprocessing policy is not just to say it's all right to resume reprocessing in this country. It seems to me you have to make some sort of a generalized statement about whether it is private industry or Government or a combination of both.

Mr. **Lujan**. Mr. Berick, you are correct in what our problems are. None of the officials in the State of New Mexico were voiced a big opposition to WIPP. But without discussion and input from New Mexico it moved from a military repository, to one that would have some spent fuel rods in it. Then Secretary Schiesinger said, "You are going to have veto power over WIPP in New Mexico," but then it turned out to be consultation. Suddenly the program again changed and spent fuel rods would not be emplaced and the program then reverted back to strictly military. Then in the middle of discussions attempting to work out an agreement between the State and Federal Governments all of a sudden DOE makes the announcement it is going in regardless of what the State wants. These actions have brought about increased opposition just because of the way it has been handled.

I think we are willing to move ahead with WIPP but in cooperation with the Federal Government and I think that whole thing could have moved very nicely with only some minor opposition because there are those that anything that would help to generate electricity by nuclear are going to be opposed to it. I think it is this vacillation by the Government that keeps us from moving forward.

Let me take this step by step. Everybody says, well, the technology is there—the problems are political. That is what I hear generly. So since the technology people have solved their problem, let the political people solve the other end of it.

Let me take you down to what I at least would consider a way to finally get the problem solved. First of all, we have the short-term problem. What are we going to do with those spent fuel rods? Away from reactors storage, I guess, is probably the only way. Is there any disagreement with that? Is that the very first step that we have to take?

Mr. BERICK. I would disagree with it.

Mr. LUJAN. What do you suggest?

Mr. BERICK. There is an interim storage problem. I think everybody agrees that there is an interim storage problem.

Mr. LUJAN. What do you do with those spent fuel rods, until such time as my next step which is going to be reprocessing? Until such time as you reprocess, what do you do with it then, if you don't agree that we ought to have it away from reactor storage?

Mr. BERICK. I think to a large extent, we should maintain the status quo, which is there is a variety of interim storage options available.

Mr. LUJAN. You can't keep status quo because every day the nuclear power plants are spitting out spent fuel rods.

Mr. BERICK. That is right, but there is commercial away-from-reactor storage; there are plans for on site expansion; there are plans at the Tennessee Valley Authority to build new pools onsite. There is a range of spent fuel storage options.

Mr. LUJAN. Leave them at the site; that is what you are saying?

Mr. BERICK. I think there is a real advantage to leaving it at the site and not having two additional transportation trips from the site to away-from-the-reactor storage, to a repository, or to a reprocessing point.

Mr. LUJAN. Well, because of the transportation angle then, you say leave them at the site, expand the site, or do whatever, but the big problem as far as you are concerned is the transportation problem?

Mr. BERICK. That is essentially the major problem.

Mr. LUJAN. Certainly that is a decision that can be made by somebody; either we are going to have the authority or we are going to extend it as such.

Mr. BERICK. I think that there is a larger question as to whether that is a Federal decision. We have commercial away-from-the-reactor storage facilities now.

Mr. LUJAN. Where?

Mr. **Berick**. At Morris, Ill. That is in operation, and that is receiving and is storing commercial spent fuel. The question is—is it necessary for the Federal Government to establish away-from-reactor storage?

Mr. **Lujan**. No. The question is just the opposite—that we stopped Barnwell—that could be used as a commercially operated AFR.

Mr. **Berick**. No. We've stopped it as a reprocessing facility.

Mr. **Lujan**. There are not any fuel rods being stored over there. So I gather that it has even been stopped as away-from-reactor storage.

Mr. **Berick**. Allied General Nuclear Services has consistently opposed the idea of using that facility as an away-from-reactor storage facility.

Mr. **Lujan**. But, if they thought they should open it up, your organization would not have any objections to it?

Mr. **Berick**. Not if we went through a licensing process and resolved that there were no problems with turning it into exactly the facility they intended to license.

The problem is whether the Federal Government is going to do it and the fact that the Federal Government has become the problem. One of the reasons why those commercial facilities have not developed is we have been holding out this Federal "carrot;" and, since 1977 when the Carter administration said—we will do the job—there has been disincentive for anyone else to get into the business.

Mr. **Lujan**. I don't think they can get a license today to open up any site; do you?

Mr. **Berick**. They are in the process of renewing a license for Morris, Ill., right now as far as I know. Three weeks after the Carter administration put a moratorium on reprocessing, GE was down at the NRC saying—we want to expand the facility.

Now they stopped saying they wanted to expand the facility when the Carter administration said—we'd like to buy it.

Now I think you have a problem here where the Federal Government has become, as it often does, the problem. It has become a disincentive for the private sector to develop the facilities and develop the storage capability and to provide the certainty as to what the policy really is that it is going to allow the utilities to make the decisions they need to make on spent fuel management.

Mr. **Lujan**. So whether it is AFR or on-site storage, the technology exists. Then the next step is, if you've spent fuel waiting, to do something with them—either stick them in the ground or reprocess them.

Mr. Snipes, you said to make these repositories accept spent fuel. Isn't that rather ridiculous? I didn't say the statement was—the notion, perhaps.

My understanding is that, first of all, there is economic value there, probably $5 million per year per reactor. We are talking about 70. That is $350 million a year that you are going to stick in the ground. That does not make sense.

The second is that, if you reprocess what is left, if you just put in the spent fuel rods, you are looking at 10,000 years. If you reprocess, you are looking at 300 years.

Are those two assumptions correct or generally?

Mr. **Snipes**. In terms of the comparison with the ore body, that sort of comparison, you are probably correct.

Mr. **Lujan**. Your statement that we design them for various spent fuel rods was not necessarily to say that we should not reprocess them?

Mr. **Snipes**. Very definitely not. What we are saying is, in making a decision here, in early 1981, we do not have the statement from the President; we don't have the statement from the Congress. We all seem to be helpless in terms of lending some certainty as to whether the policy of the Nation is going to be reprocess spent fuel or not reprocess spent fuel.

We are sitting here early in 1981 looking at the scope under which the demonstration of repository facilities should proceed. We believe that it would be prudent to look to a facility, the design of a facility, which could accept either waste form.

Mr. **Lujan**. We have no problem then with the technology of storing because we are doing it now. We have no problem with the technology for reprocessing because we know all about it. We are doing it and have done it with military waste, so those first few steps, from a technology standpoint, are no problem.

Then the third one, what is left after reprocessing—solidification—where are we with that? Do we have any problem with technology in that? Can we solidify right now?

Dr. **Lieberman**. The short answer is, yes.

Mr. **Berick**. And the long answer is—is that waste form and that technology adequate to contain the waste for the period of time that we are talking about in the geologic repository conditions that we may develop.

Mr. **Lujan**. If it isn't, then why not a steel container that lasts the number of years that is necessary to contain it until it decays down to its natural state? Do we have that technology?

Dr. **Witherspoon**. You may know the Swedes at one time were proposing a canister, not of steel, but of copper, 20 centimeters thick for each cannister. The reason it chose that was their calculations indicated it would last for hundreds of thousands of years, but I have not heard much about that in recent years. Some people have said that, when they got all of the canisters with 20 centimeters of copper around them, it would be more like an ore body with the waste, and then someone would be after that copper.

Mr. **Lujan**. Well, 300 years from now, it could be the case.

So the only problem then is, if we could do all of these things and put them in the proper container, find out where to put it. It seems to me we have dug enough holes all over this country that we ought to have some idea. If you are talking about the granite, or basalt, or salt domes, or whatever, it is not that necessary that no water gets in. We have those kinds of canisters. Why is it so difficult? It seems to me, just from a very practical standpoint, without all of the scientific knowledge—that is not my area—if you were in that business, that those various steps can be accomplished. What is wrong with that kind of a solution? Why do we need to study it, other than to make it better?

Dr. **Witherspoon**. Did I hear you say 300 years would be sufficient?

Mr. **Lujan**. That was my general understanding.

Dr. **Witherspoon**. I hear so many different numbers. This seems to be the shortest time period that I have heard.

Mr. **Lujan**. Well, when we are trying to prove a point and if we want to make it look bad, we use 10,000 years. If somebody wants to make it look good, they will use the 300. But certainly it is 10 times less, 20 times less, by reprocessing than by not reprocessing. That is really the point that I was trying to make.

I don't know that I have given you room for an answer. I have given you my own way of how we ought to do it, but it sounds like it is something that is practical and can be done, and we are going to put in I don't know how many hundreds of millions of dollars for DOE to study it when we ought to be buying the canisters and setting up the reprocessing plants.

Mr. **Snipes**. From our perspective, our answer is yes, to everything you have said.

Mr. **Lujan**. Thank you.

Mrs. **Bouquard**. Mr. Lujan, I think you have provided the essence of this hearing this morning.

Mr. Volkmer?

Mr. **Volkmer**. I would just like to echo Mannie's last statement, and I think it is time to get on, too, and I think it is time that the American people want to get on with it. If we continue to study it—oh, we could study it and study it and study it, and try to reach the time when we have perfection, but we are never going to have perfection. We can always probably create something maybe a little better. Maybe 10 years from now, somebody might say—well, they should not have done it that way; we should have done it some other way—but I don't think we should wait to find out 10 years from now another way to do it. I think it is time to move forward and I think we should move in that direction.

The only one I understand that may disagree to some extent is Mr. Berick; is that right?

Mr. **Berick**. That is right.

Mr. **Volkmer**. Give me again your reasoning for disagreeing with that.

Mr. **Berick**. We are not opposed to moving ahead. What our objection to the proposal is, is that you are talking about a new step—a new program, a new project, a new facility—that may not in reality gain us anything. There has been a lot of talk this morning about doing everything in parallel. Well, we aren't going to have the luxury of doing everything in parallel, as the Congress knows all too well. We are not going to have the money to do the things we need to do in parallel.

We have a situation where we are going to have to choose and choose carefully as to where we make our investments and what kinds of facilities and what kinds of programs we get underway. I think that that is an especially necessary task.

We ought to sit down—to some extent as Congressman Goldwater's bill lays out—and lay out what the uncertainties are, what research issues need to be resolved, what are the uncertainties, what are the glitches that people don't agree on in terms of waste, vitrification, or how long the stuff should be stored, and then address those and spend our dollars where the problems are.

I don't think there is agreement about the problems, and I certainly don't think there is agreement about the need to go out and spend a significant amount of money on facilities that may not really address, and certainly not address in an economically sensible manner, those particular problems.

We have test facilities. We are going to put waste in the ground in different kinds of different geologic formations under already existing programs.

The question that I have is are these new proposals that have been laid out in this legislation really going to be cost effective, are they going to help us solve the problem, or are they going to be one more disruption, one more distraction, one more tangent, that we send the folks at DOE and Battelle, and other places, off on to demonstrate something that really doesn't get us around to answering the questions that need to be answered.

Mr. VOLKMER. Well, I would take the position that the scientists, DOE, et cetera, should make a determination which is the best process for waste disposal right now. Decide what is the known and the best process, and not spend a lot of additional time on it. You've got the studies. You've got the tests and everything else. Arrive at some conclusion and let's do it—period.

Now as far as the rest of the studies, the ongoing studies, some of those, as far as I am concerned, you can just throw them away for the time being. That is where I want to save the money.

Mr. BERICK. I think we are sort of in general agreement about that. We might disagree about exactly how those decisions should be arrived at, but I think there is general agreement about that. There are some programs now underway. There has been 2 years worth of discussions between the U.S. Geological Survey and the DOE Office of Waste Management about exactly what kinds of research needs to be done to answer what kinds of questions. Those things are being done.

Mr. VOLKMER. And you still are going to have unknowns when those are done. You are still going to have unknowns. My point is you are never going to have the 100-percent positive solution that everybody would like to have. You are going to have some unknowns. We can keep on studying those unknowns. There is no point in my opinion of doing that. We disagree on that. I can see that.

I am willing to take a risk. You have to take a risk somewhere. I am willing to take a risk.

Mr. BERICK. Let me make a constructive argument, if I may, which is that this unlike other kinds of enterprises has one final hurdle, and a very large hurdle, which is that, if we are going to have these commercial waste repositories, they are going to have to be licensed unless we go and change the law.

We are going to have a very large hurdle out there of NRC licensing process and court suits which you and I both know are going to occur.

There are very large hurdles at the end, and the fact that there are uncertainties, and we would like to make some clear-cut decisions to circumvent some of those uncertainties, in some ways, just is not practical. It is not practical because people are going to come back to those uncertainties.

The question is do we know enough about the uncertainties to convince the NRC to convince the courts that they are not serious uncertainties, or they are not out of hand, and they will not compromise the public health and safety.

Those are the kinds of things that have to be addressed in designing the program. There is a very large hurdle at the end of the road, and that just cannot be overcome by just direct programs.

Mr. **Volkmer**. Maybe I didn't go further than some of the people who are proposing the legislation. I thought for some time that maybe the only way we are actually going to have a full-scale, large commercial waste disposal is give power of eminent domain, and I mean against the States and everybody, and just do it, and that is the only way it is going to be done.

You can file all the lawsuits. Anybody can file all the lawsuits they want with the power of eminent domain, and I think that we can handle it just like we do for highways and we do for electrical power lines and everything else. I think it can be used in this instance for waste disposal and I think it should be.

The other thing that I do believe in, though, and I would like to have the answer of the other panels, Mr. Lundine asked about the cost of waste disposal, and I think we have to look at setting up some type of methodology so that those that produce the waste do share in that and we have some guarantees on that. I think we are going to have legislation on that.

To be honest with you, I don't believe, personally, that we rely purely on the private enterprise system just to take care of it and do it properly. I think there has to be guidelines, and I think there has to be a methodology in doing that.

The same way on reprocessing, and I have no objection to reprocessing as long as there is sufficient safety, et cetera, is done properly, et cetera.

I question Barnwell to be honest with you. As to the facility itself and the operation, I think it will be operated upgraded from what it was in the past.

I do believe that that should be also the subject that those who use it should pay for it. I think that has to be looked at, and I think it can be done.

It is my understanding that, in West Germany right now, there is a consortium, private, mostly public—some public utilities—that are going to do the same thing. They are going to have their own reprocessing, working with the Federal Government.

I think we can do a similar thing right in this country.

That is the end of my statement.

Thank you, Madam Chairman.

Mrs. **Bouquard**. Thank you very much, Mr. Volkmer.

We are running out of time, but I just want to ask one final question to Mr. Berick.

How are the courts going to decide scientific risks unless we do the comparative risk assessment studies which I understand that many environmental groups are against—if we can summarize that rather quickly? How are you going to do this?

Mr. **Berick**. I don't know that environmental organizations in the nuclear area are opposed to doing kinds of risk assessments that you are talking about.

The objections that a lot of people have had is that 50,000 people a year get killed on the highways; and, therefore, nuclear power is safe because it does not kill 50,000 people.

Mrs. **Bouquard.** Mr. Berick, will you oppose that in our bill—in our nuclear safety bill? That was one of the features that was opposed by the environmental groups.

Mr. **Berick.** Well, people are not opposed to doing risk assessments. Risk assessments are going to have to be done. The question is are the risks that one is comparing among technologies? There is opposition to that and there is opposition to the kinds of—let's say the apples and oranges arguments where you compare the risk of coal and you compare the risk of nuclear, both of which have substantial uncertainties, but you can say one is higher than the other; and, therefore, this technology should be pursued. You are absolutely right that there is objection to that, just as there is objection on the further extreme position—and I have been in enough forums to hear the argument that 50,000 people get killed on the highways; and, therefore, the risk from nuclear power is acceptable.

There is objection to comparative risk assessments. There really is not objection to risk assessments, especially risk assessments based upon experimental and epidemiological data, and that there is growing support for, and we are urging that that kind of work be done.

Mrs. **Bouquard.** But Mr. Berick, you just got through saying that there will be court cases?

Mr. **Berick.** Yes, ma'am.

Mrs. **Bouquard.** Unless we go ahead with this sort of R. & D. program, how could a court decide a scientific risk unless we do have this type of comparative risk assessment study?

Mr. **Berick.** I think they will be asked to determine whether the risk assessments that the Department of Energy has done are valid analyses. I am not sure the courts are going to be asked to look at relative risks. I don't think the arguments that we find at the end of the road are going to be based upon those kinds of issues.

Mrs. **Bouquard.** What are the issues do you think will be decided by court?

Mr. **Berick.** I think they are going to be very technical issues. I think you are looking at a process where we are talking about decades of environmental impact statements, and site characterization reports to the NRC. We are looking at a fairly technical process at the end. We have encouraged and urged the Congress to pass legislation that bounds those kinds of issues. I just think that is the direction.

I don't think we are going to be opposing or find opposition to waste repository siting on the basis that solar is safer than nuclear. I just don't think those are the issues that are going to be taken into courts.

Mrs. **Bouquard.** I think we have run out of time. I would like to pursue this further.

Thank you, gentlemen, for being with us today. We appreciate your input, your time, and the effort you put into your testimony.

We are going to resume our hearings now.

We are now going to hear about a nuclear program which has received unwavering congressional support in the face of considerable vacillation on the part of the DOE. If the nuclear licensing and regulatory climate were at all reasonable, then I am certain the private sector would be going it alone with HTGR.

The HTGR program has lacked strong direction from the Department for the past 4 years, but I expect it to be treated a bit better by the new administration. Our committee has always supported funding of the HTGR even when the DOE was uncertain as to what was the most effective path for its development. I believe that the applications of this concept for other than electrical generation dictate careful consideration and prudent funding of this program. I also want to mention that I have offered a successful amendment to restore HTGR fuel cycle funding for 4 years in a row.

I certainly would like to welcome our four witnesses. Here with us are: Mr. Harold Agnew, president of the General Atomic Co.; Mr. Richard F. Walker, president of the Public Service Co. of Colorado; Mr. Robert Uhrig, vice president of Florida Power & Light; and Mr. Robert Richards, who is general manager of the Advanced Reactor Systems Division of the General Electric Co.

Gentlemen, you may proceed with your testimony.

## STATEMENT OF HAROLD AGNEW, PRESIDENT, GENERAL ATOMIC CO; RICHARD F. WALKER, PRESIDENT, PUBLIC SERVICE CO. OF COLORADO; DR. ROBERT UHRIG, VICE PRESIDENT, FLORIDA POWER & LIGHT; AND ROBERT RICHARDS, GENERAL MANAGER, ADVANCED REACTOR SYSTEMS DIVISION, GENERAL ELECTRIC CO.

Mr. AGNEW. Madam Chairman, my name is Harold Agnew. I am president, General Atomic Co.

What I would like to do is work from these charts. I believe you have a copy of them.

Mrs. BOUQUARD. That is very kind of you. Thank you.

Mr. AGNEW. Clearly understanding the advantages of this particular technology, I guess to me with my background in the defense field, safety is something I consider to be paramount. Right behind that, of course, is the high-thermal efficiency that one obtains from this particular technology.

Then looking to the future, this reactor is unique in that it is the only nuclear system that we can see today which can have direct application toward process heat at all temperatures of interest. I think we should not lose sight of this long-range potential.

Now this particular technology has an interesting history. I think you are aware that Peach Bottom reactor ran very successfully for 7 or 8 years. It was then followed by the Fort St. Vrain reactor which is presently running.

Mr. Walker is President of the Public Service Co. of Colorado. He will give you the specific details on that particular plant.

What we are talking about today is this particular plant which the committee will be considering for construction authorization. The plant as we envision it is an 860 megawatt electrical plant for generating potential, but specifically—and I think this will be addressed later in the testimony of the utility people—it would be the first real commercial version of a plant from which we would expect all the advantages that we have outlined in the first viewgraph; and, at the same time, would lead in the future toward the process heat applications, direct cycle. You mentioned there has been continual ratcheting back and forth by the Department of Energy and ERDA and the OMB, whereas 1 year it is straight steam cycle, the next year it is a gas turbine, and the next year it is process heat. I think there has been legitimate concern on the part of the Congress where we are going.

I think, perhaps due in large part to Congressman Lujan's work, we have the technology. Let's quit studying it. Let's demonstrate to the world what we can do. In that context I should point out that this program is unique in the nuclear programs. This is the only nuclear program where the private sector has contributed more money than the government. By that I don't mean a 51/49 split.

If you look here on the Peach Bottom reactor, the ratio of moneys which were involved was something like 6 to 1 private over Government. On the Fort St. Vrain, and that is why, in this particular case, the owners are reluctant to go all by themselves for this development, it is about 12 to 1—the total moneys that the industry has put in compared with the Government. The industry put in about $600 million. The Government put in $47 million.

So I think the industry has shown faith in this particular development.

What we are planning, of course, is looking ahead for this particular specific plant demonstration which your committee will be studying. If you average the amount of money that we would hope to have the government put in, it would be about one-third of the total input; but, over the 12- or 13-year period, it is about $26 million a year.

I think one should consider the benefits downstream to the country and to the interest of the American public being able to use uranium, which is unique, the only other uses I know of is in making glass, or in making ballasts for airplanes or ships.

We have this tremendous resource, if we can utilize it in an efficient way. These reactors use about 30 percent less uranium than any of the other reactors. The total call on our resource is less. The efficiency, of course, ties in with that. It is very high, and it provides the opportunity downstream for these other uses.

It is just something I think is a very prudent investment for the country. Then you couple that with this reactor's inherent very forgiving design.

This term "forgiving" design which goes with the HTGR is actually a British term, and I found the history of that. The history goes way back to the battle of Britain where the RAF had liquid-cooled engines and gas-cooled engines in their air defense aircraft—fighter aircraft.

The air-cooled engines when they received enemy fire were much more able to survive hits than with liquid-cooled engines because, with the liquid-cooled engines if they broke one of the glycol lines, that was the end of the engine.

So the British in their unique way of expressing things, would just say, "I got back, old chap, because this is a very forgiving design."

In the same context, the gas-cooled reactor systems are much more forgiving, as consideration of Three Mile Island has shown. Fort St. Vrain has had problems, but they have been able to handle them, along with not circulating coolant for several minutes, fifteen minutes, I guess, in these particular designs compared with the water systems where you have to react within a few minutes or fractions of a minute.

As Commissioner Hendrie pointed out in his testimony last year, gas-cooled reactor designs provide hours or tens of hours before you have to react.

We are certainly better in the nuclear inner scene with regard to operation and training. If you can have a design which inherently allows for more time to react, I think, we will all be better off and this technology provides that.

Now we are not alone in this particular development. There are extensive programs in Europe, Japan. The major program is the German program, and the Japanese program is rapidly building up.

If you notice the money levels for let's say 1980, where our money level was something around $43 million for the total program, you will notice that the Federal Republic of Germany and Japan had moneys which totaled about $250 million. They see the advantage of this technology.

One could call it an analogy between small cars and big cars. They have looked at this technology. They see where it is going to go, especially toward industry for process heat. In the long run, they see the advantage of, let's say, the insurance or the protection of the equity because of its forgiving nature. It is a safer reactor. I think we have shown that the public, as far as their personal safety is concerned, is well taken care of and well served by the present water systems; but, for the person whose equity is in the plant, there is a question being raised.

I think we should maintain our private utilities systems in this country. That system depends upon the private investor who is willing to put his money into bonds, into the structure for the plants; and, he worries, then that he could be wiped out. I think that the private utilities are in for some hard times for cash.

This technology—when you can stand up in front of the stockholders and explain that their equity is much less at risk than any of the other systems, then you would expect that with 35 years of development there should be a new technology being brought on line.

As I illustrated there is a very vigorous program worldwide, and I would hope that we would not be left behind.

That Madam Chairman concludes my remarks. We have Mr. Walker, Mr. Uhrig. If you have any specific questions you wish to address to me, I would be happy to respond.

[The prepared statement of Mr. Agnew follows:]

# FY'82 DEPARTMENT OF ENERGY AUTHORIZATION
# HIGH TEMPERATURE GAS COOLED REACTOR

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE
U. S. HOUSE OF REPRESENTATIVES

HAROLD M. AGNEW, PRESIDENT
GENERAL ATOMIC COMPANY

FEBRUARY 26, 1981

## I. INTRODUCTION

The High Temperature Gas Cooled Reactor is an advanced, high efficiency, converter reactor system which, in addition to electrical generation, offers a unique capability to meet industrial requirements for high temperature process steam and process heat. The basic technology has been demonstrated by the Peach Bottom I (40 MWe) and the Fort St. Vrain (330 MWe) nuclear stations, wherein high temperature and high pressure steam is generated to produce electricity. The next stage of HTGR development is the demonstration of full scale commercial technology.

The current DOE/Industry program is focused on the unique high temperature capabilities of the HTGR to provide process steam and process heat for industrial applications. The near term application of the HTGR is to generate high temperature (1000°F) steam for process heat use in chemical, oil, shale oil and metals refining industries. In these applications, nuclear process heat substitutes directly for fossil energy. Most process steam applications involve the simultaneous cogeneration of electricity to efficiently use the energy produced by the system. This version of the reactor is the HTGR Cogeneration system.

Longer term applications involve HTGR reactors with higher operating temperatures. These reactors can serve higher temperature process heat markets such as methane reforming, direct coal gasification, and eventually direct water splitting for hydrogen production. At the higher operating temperatures, the HTGR may also be used to generate electricity using closed cycle helium gas turbines with overall efficiencies of up to 50%. The latter systems using dry cooling towers are particularly suited to location in water-scarce areas.

## II. JUSTIFICATION

High Temperature Gas-Cooled Reactors offer higher thermal efficiencies than the existing LWR technology as well as improved fuel utilization by employing the uranium/thorium fuel cycle. The HTGR has inherent safety characteristics; i.e., inert helium gas as a coolant, prestressed concrete reactor vessel and massive high-heat capacity graphite core, which significantly reduces both the likelihood of accidents and the consequences to the public and facility itself. The HTGR is the only reactor capable of producing the high temperature steam to meet the industrial requirements of the oil, chemical, synfuels and aluminum process industries and displacing the substantial quantities of fossil fuels otherwise required. Estimates of existing process steam markets (e.g., in oil and chemical industries) indicate that more than 70 reactors could be deployed to meet existing needs, saving the equivalent of 1-1/2 million barrels of oil per day. Future markets in support of the synfuels industries would add substantially to the total potential market.

A major segment (30%) of the electric utility industry and major oil, gas, process steam users and chemical firms support the development of gas reactors through organized user associations. Through FY'80 private industry has invested over $1 billion and the government has provided $350M to develop this technology. It is the only nuclear program which has received the majority of its development funding from the private sector.

The value of the HTGR for process heat applications has been recognized in West Germany and Japan. Both countries have established HTGR development programs with 1981 national budgets of $250M and $25M, respectively. The U.S. has established a formal cooperative program with Germany, which includes the exchange of both technology and personnel. The Japanese have indicated the desire to explore a similar relationship.

## III. MULTI-YEAR SCOPE AND SCHEDULE

### HTGR Cogeneration (HTGR) Lead Project

The current program is focused on the development and demonstration of a 2240 MW thermal HTGR process steam/cogeneration plant. To minimize the magnitude and open ended nature of the financial commitment, the program has the following features:

1. A phased program with decisions required at defined milestones.
2. The requirement for direct participation by an organized, internally funded, users group which functions establish the plant owner/operators and develop the private sector cost and risk-sharing mechanisms.
3. The requirement for the private sector to provide the substantive funding of the construction of the HTGR demonstration plant.

These features serve to focus the government's investment principally on the development and proof testing of the HTGR technology for the demonstration facility. Financial and performance risks would be well defined and shared among users, suppliers and the government. The progress of the program through the several phases preceding construction of a demonstration plant would require agreement at each phase by all the participants on cost and risk-sharing in the next phase.

Phase I (Program Definition - FY'81) is being directed toward reviewing and prioritizing the HTGR design and development requirements for an HTGR process steam cogeneration plant project. Candidate plant operators and sites are being identified. Detailed program planning for Phase II will be completed. The HTGR technology development will continue to focus on the near-term applications of the HTGR. The milestones identifying the completion of Phase I consist of:

1. HTGR Lead Plant definition
2. Identified candidate operators and sites
3. Detailed program plan (including costs and benefits) for following phases

Specifically during FY'81 the HTGR Applications Program will advance the HTGR-Process Steam/Cogeneration plant conceptual design by completing the top-level technical documents and specifications. Design of key critical path components such as the steam generator and circulator, will be significantly advanced. Evaluation of safety features in light of the Three Mile Island accident will be completed. Technology development requirements will be identified and long-term design and development plans for major systems and components of the HTGR-NSS will be issued.

During FY'81 the HTGR Technology Program will continue work on development of low-enriched uranium/thorium fuel cycle. The reference fuel form, fuel process and details of the fuel cycle will be selected. Basic data, information and technology in the areas of structural materials, safety and nuclear heat source components will be provided. Critical path component design verification testing will be initiated.

Phase II (Project Definition - FY'82 and FY'83) is focused on the preparation of a decision package for proceeding to Title I design. This decision package will contain the plant conceptual design, schedule and cost estimates, Environmental Impact Statement (EIS) and project management plan. During Phase II, the lead plant operator/owner and a site will be identified. Generic Licensing topical reports will be completed and reviewed with the NRC. The HTGR technology development efforts will be directed principally to support the conceptual design and licensing efforts, including testing of key components.

Phases III and IV (FY'84 - FY'87) will be devoted to the development of Title I (Preliminary Design) and Title II (Final Design) designs and the associated licensing efforts. The output will include successively more detailed cost estimates and schedules, as well as the management and cost sharing plan. At the conclusion of Phase IV, firm priced bids will be available on all major plant components. These outputs will provide the decision packages for proceeding to Phase V, Demonstration Plant Construction.

The primary responsibility of the government in the Cogeneration Demonstration Program will be to support the development of the appropriate technology and first-of-a-kind design. The commercial value of the demonstration plant will be provided by the private sector.

## IV. MULTI-YEAR BUDGET ESTIMATE

### Projected 2240 MW Thermal HTGR Cogeneration Project Funding, FY'81 - FY'94 (1980 $M)

Summary of financial participation over program life.

| | | |
|---|---|---|
| - | First-of-a-kind design, development and engineering | $ 350 Government |
| - | Equivalent plant capital cost commercial value | $ 763 Private |
| - | First-of-a-kind plant capital costs and technical and cost risk (extent and sharing determined prior to commitment to build) | $ 138 Joint (Government and Private) |
| - | Total Program Cost | $1251 |

## Funding Schedule - Cogeneration Project Research and Development Design and Design Verification and Testing (1980 $M)

| | |
|---|---|
| Phase I - Program Definition | |
| FY'81 | $ 26 |
| Phase II - Project Definition | |
| FY'82 | $ 36 |
| FY'83 | $ 46 |
| Phase III - Title I | |
| FY'84 | $ 55 |
| FY'85 | $ 54 |
| Phase IV - Title II | |
| FY'86 | $ 45 |
| FY'87 | $ 34 |
| Phase V - Title III | |
| FY'88 | $ 19 |
| FY'89 | $ 13 |
| FY'90 | $ 9 |
| FY'91 | $ 8 |
| FY'92 thru '94 | $ 5 |
| TOTAL | $350M |

## V. HTGR FY'82 BUDGET DETAIL

### HTGR Cogeneration Plant Program

| | |
|---|---|
| Plant conceptual design and technology | $50M |
| Fuel treatment technology | 5 |
| Advanced HTGR technology | 5 |
| TOTAL | $60M |

## Recommended HTGR Program Approach

The $60M request for FY'82 funding of the HTGR program will provide the following:

Establishment of a coordinated and integrated overall HTGR Program Plan, which will:

1. focus the overall technical effort,
2. lead to a demonstration of design and process technology, licensability and operability of the HTGR,
3. retain user, industry, Congressional support, and
4. establish the industrial capability and technical basis for all HTGR systems.

The phasing and private sector participation in the program will minimize risk and open ended commitments to all participants.

In addition, the HTGR Fuel Treatment Program directed by the Oak Ridge National Laboratory will be continued with FY'82 funding of $5M.

* * * * * *

GENERAL ATOMIC

FY'82 DEPARTMENT OF ENERGY AUTHORIZATION
HIGH TEMPERATURE GAS COOLED REACTOR

# SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
# HOUSE SCIENCE AND TECHNOLOGY COMMITTEE
# U.S. HOUSE OF REPRESENTATIVES

HAROLD M. AGNEW, PRESIDENT
GENERAL ATOMIC COMPANY

FEBRUARY 26, 1981

# HTGR CHARACTERISTICS

- HIGH LEVEL OF INHERENT SAFETY
  - ADDED PLANT INVESTMENT PROTECTION
- ELECTRICAL GENERATION AT HIGH NET THERMAL EFFICIENCY
  - LOW COOLING WATER REQUIREMENTS
- LOW RADIOLOGICAL DISCHARGES
  - REDUCED PLANT OPERATOR EXPOSURES
  - SMALL OFF-SITE RELEASES
- FLEXIBLE URANIUM/THORIUM FUEL CYCLE
  - REDUCES $U_3O_8$ REQUIREMENT 25-50%
  - USE OF LOW TO HIGH ENRICHED FUELS
- LESS SUSCEPTIBILITY TO TRANSIENTS OR UNEXPECTED OCCURRENCES
  - HIGH "THERMAL INERTIA"
- GREATER ACCESSIBILITY TO EQUIPMENT DURING PLANT OPERATION
- HIGH TEMPERATURE CAPABILITY ALLOWS INDUSTRIAL AND PROCESS APPLICATIONS
  - DISPLACES FOSSIL FUELS IN NON-ELECTRIC AREAS

# HTGR SYSTEMS & NATIONAL ENERGY ROLES

HELIUM OUTLET TEMP

950°C

VERY HIGH TEMPERATURE PROCESS HEAT
  - THERMOCHEMICAL HYDROGEN PRODUCTION
  - DIRECT COAL GASIFICATION

850°C

PROCESS HEAT FOR REFORMING
  - SUBSTITUTE PIPE LINE GAS
  - TRANSPORTATION LIQUIDS
  - THERMOCHEMICAL ENERGY TRANSMISSION

HIGHER EFFICIENCY ( 50%) GENERATION
  - ECONOMICAL DRY COOLING
  - COGENERATION

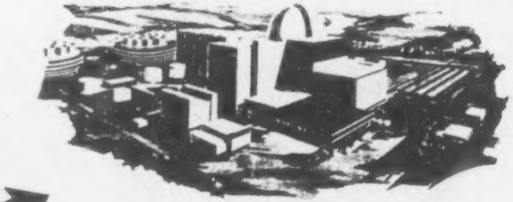
750°C

HIGH EFFICIENCY ( 40%) ELECTRICITY GENERATION

PROCESS STEAM
  - PROCESS & SYNFUEL INDUSTRIES
  - CHEMICAL/PETROCHEMICAL INDUSTRIES
  - HEAVY OIL, TAR SANDS RECOVERY

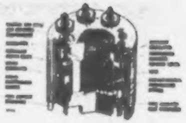
PEACH BOTTOM NO. 1
PROTOTYPE 40 MW(e)

FORT ST. VRAIN
DEMONSTRATION
330 MW(e)



HTGR LEAD PLANT
860 MW(e)/CO-GENERATION

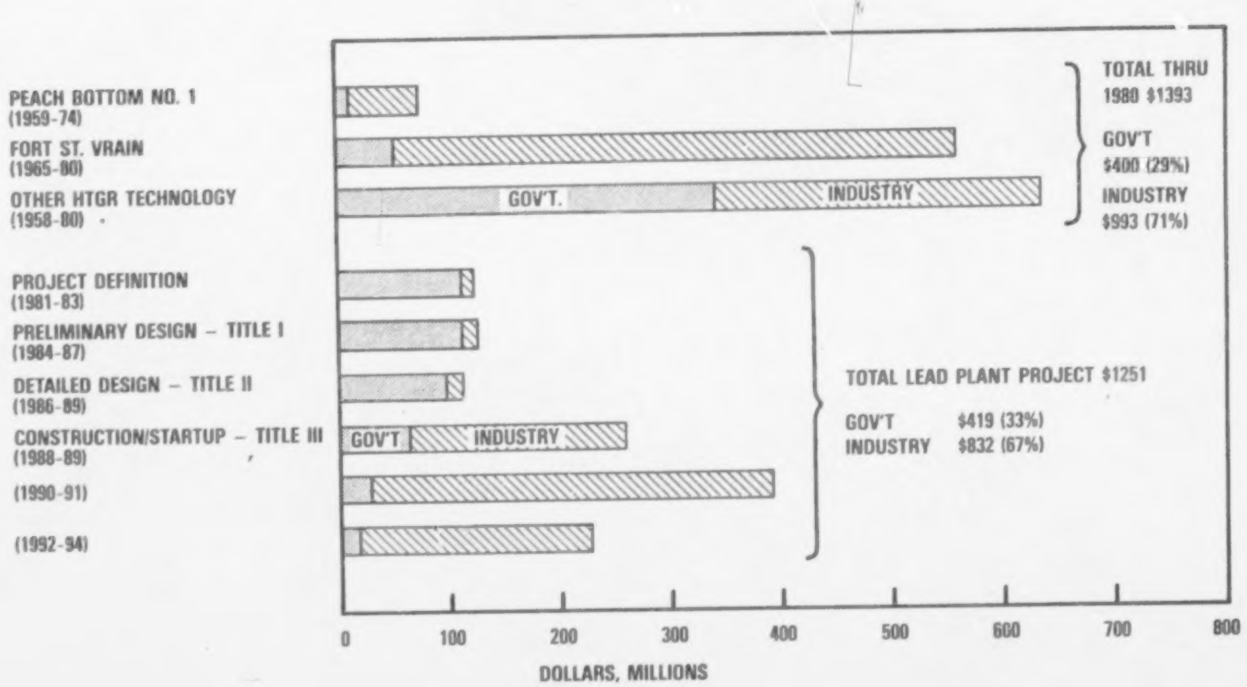
HTGR PROCESS HEAT



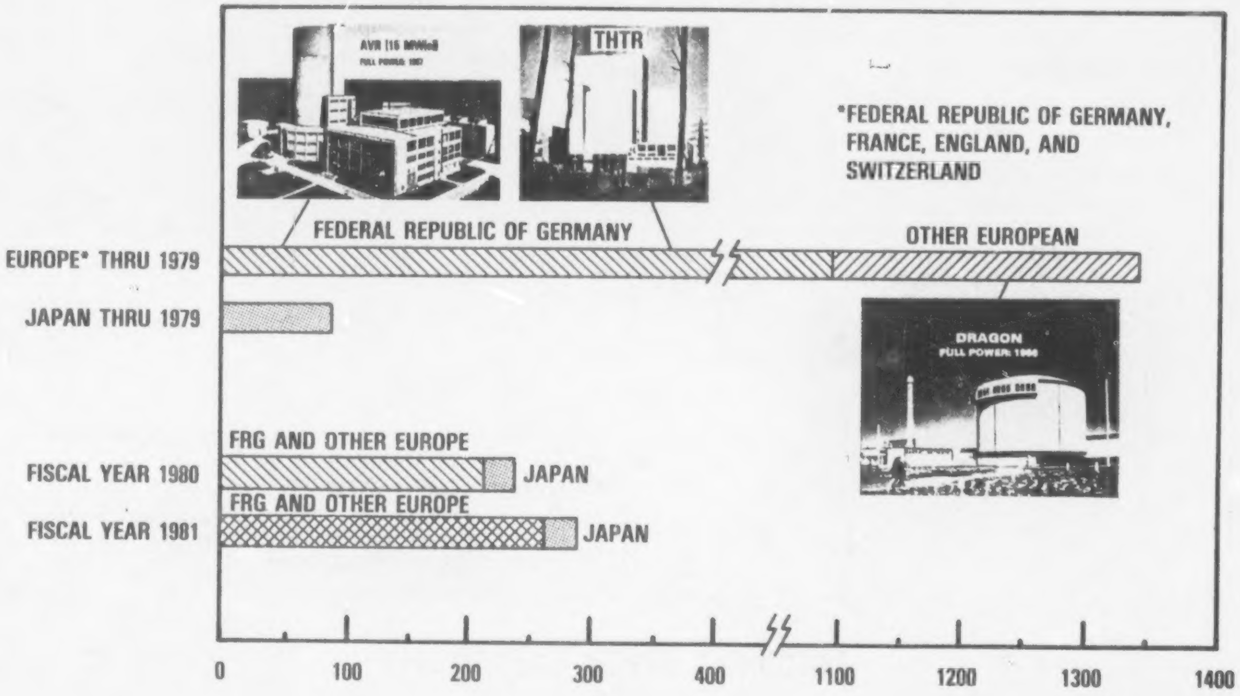
VHTR

HTGR GAS TURBINE

# DOMESTIC HTGR PROGRAM FUNDING

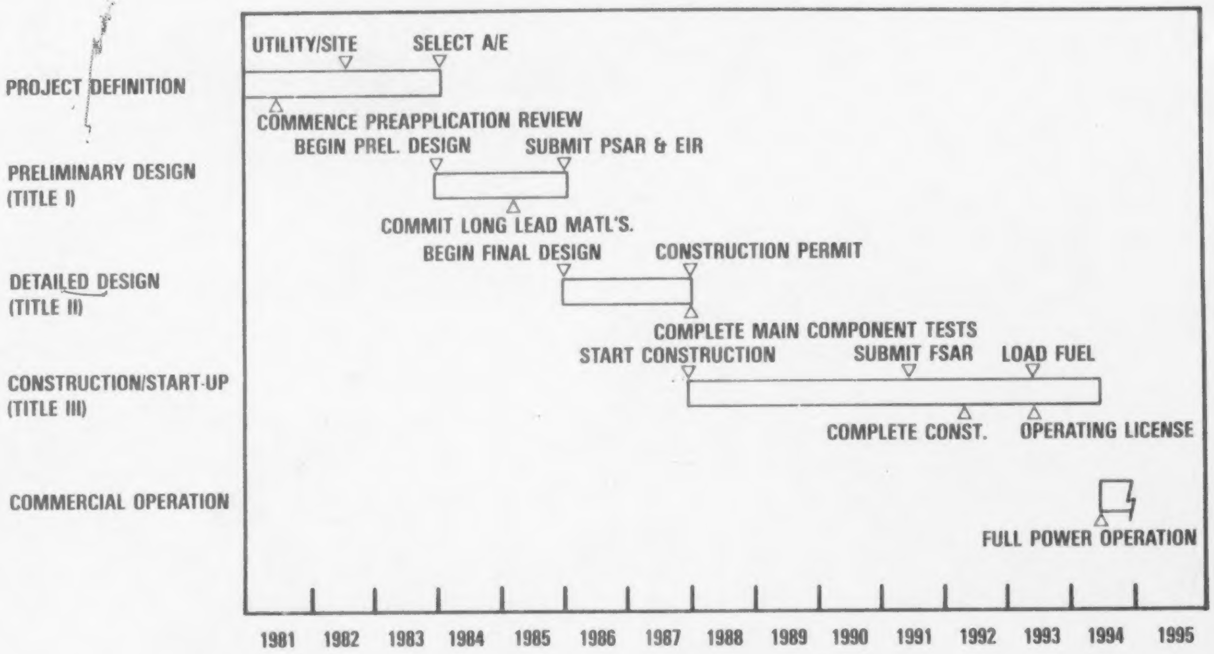


# INTERNATIONAL HTGR PROGRAM FUNDING



*FEDERAL REPUBLIC OF GERMANY, FRANCE, ENGLAND, AND SWITZERLAND

# HTGR LEAD PLANT SCHEDULE



Mrs. BOUQUARD. I thank you for your testimony, Dr. Agnew. I think we will address our questions to all of you as a panel. That was beautiful testimony.

Mr. AGNEW. Thank you very much.

Mrs. BOUQUARD. We certainly do appreciate it very much.

Mr. Walker?

Mr. WALKER. Thank you, Madam Chairwoman.

I am Richard F. Walker. I am president of Public Service Co. of Colorado, and chairman of the Gas-Cooled Reactor Associates, which is the utility/users group that was formed in February 1978 to support the continued development of the HTGR as an alternative nuclear reactor system.

As Dr. Agnew said, the Fort St. Vrain plant is a plant on our system. It is a plant that we entered into with the General Atomic Co. as part of the reactor demonstration program sponsored by the Atomic Energy Commission. That plant has been put on the line, and we accepted it from the General Atomic Co. in 1979 at a 200 megawatt capacity and have been running the installation at that level since we accepted it in 1979 through 1980 and into 1981. In 1979, it generated almost 5 percent of our system requirements. So far this year, January through this portion of February, it has generated from 8 to 10 percent of the system requirements for our company in Colorado.

We are pleased with it from a number of aspects—the ease of operation, the low radiation levels, and the response time to upset conditions, as referred to by Dr. Agnew.

We do have certain problems with some of the auxiliary systems and we have design work underway. Over this year and next year, we will be spending $15 to $20 million of our funds to upgrade some of those systems, to increase the reliability of the plant.

We have been working closely with the Nuclear Regulatory Commission. Which currently has a hold on our license such that we cannot exceed 70 percent of full reactor-thermal power. We are hopeful that, in a very short time, the NRC will allow us to go forward and test the plant at levels above the 70 percent to which we are now limited.

As far as the GCRA group, I am very pleased to have been a part of its formation. It has been an excellent way to bring together all of the interests that are involved in HTGR technology.

The members of our GCRA group represent about 25 percent of the electric generating capacity in the United States.

There has been another utility group called the Helium Breeder Association that has to do with the gas-cooled fast reactor program. In order to keep that structure, they are remaining in business, but they have joined our group as a group member.

If you add their membership into our umbrella group of GCRA, it represents some 34 percent of the U.S. electric generating capacity.

We also have a process heat users group of steel companies, coal companies—various people that would have an interest in the process heat. We have a working arrangement with that group because that is certainly one of the long-term benefits from this activity.

We have a counterpart of German utilities in the Federal Republic of Germany. They have a group similar to GCRA, and we are in the process of finalizing a cooperative agreement with them. This assignment will not conflict with the governmental or other industrial agreements, but will allow us to exchange information. We hope to sign this agreement with the Germans this spring. We feel that is a good step forward.

We appeared before this committee last year and talked about our work that we were going to do during the last fiscal year. That involved selecting a lead project. As Dr. Agnew indicated, we have been looking at four different projects with DOE. We have made a decision that the lead plant should be what we call the steam cycle cogeneration application. This plant produces high quality steam that could be used for electricity generation, process steam or cogeneration.

I have copies with me here today, and I am sure the staff has been furnished with these volumes, that represent the detailed work which has been done so that we could arrive at that decision.

We have made that decision in our group. Program participants agree with it, and we are proceeding on that basis.

For the fiscal year 1982, we want to get on with the program. If I could refer you to the chart that is shown on the easel, with emphasis on the section—Project Definition. We need to zero in on a site and our target date for that is sometime during 1982. We have six utilities that have indicated varying degrees of interest in being the lead utility candidates and have done some preliminary work toward specific lead project definition.

Following me, Dr. Uhrig will explain Florida Power & Light's interest in this, as it is one of the interested utilities.

Public Service Electric & Gas has also indicated an interest, so has Idaho Power Co. and three other utilities.

During 1982, we need to proceed on a more definitive design of the lead plant. Our target schedule calls for completing the design and development such that construction would start in 1987, with an operating license in 1993 and commercial operation in 1994.

Following on from this, a great deal of the work that is done with the steam cycle/cogeneration lead plant would be applicable to some of the follow-on projects that Dr. Agnew indicated. Process heat is certainly one that has a great deal of interest to many of us. It has a particular interest to me coming from the West where there are large deposits of oil shale. I guess the dream that I have for this concept is that someday we could use HTGR heat for the retorting of the oil shale, rather than have to burn the shale. This cannot be done now. There are enough difficulties involved with starting oil shale projects, but I think down the road someday, this would be an ideal thing to do. It would be an excellent application of this technology.

Mrs. BOUQUARD. This would remove some of the environmental problems for consideration; would it not?

Mr. WALKER. Yes. We have lots of wide open spaces in the West. There is a certain thing called prevention of significant deterioration that does inhibit the amount that you can do in any given area depending upon the environmental impact increments that are left available. Where we might reach that level in oil shale production before you would exceed that or whether the laws might be changed, I don't know. But I think that the oil shale industry might be limited by the impact on the environment.

Mrs. BOUQUARD. That is also a variable.

Mr. WALKER. That is very much of a variable. In any event, the HTGR is an interesting way of expanding the production of oil shale, but it is, in all candor, a good many years down the road.

There is also the direct cycle HTGR system which could build on the lead plant technology; and, if the time should come that we need an alternate breeder design, the gas-cooled fast reactor system has much in common.

Our funding request for fiscal 1982, as presented in my testimony, represents $55 million for the program involving the lead plant design and development plus advanced systems and some $5 million regarding the spent fuel treatment program.

We would certainly urge the committee to give this consideration, and we would certainly be willing to provide any backup that might be required on any more information that the committee might desire.

A few words about the cost-sharing arrangements. I think Dr. Agnew portrayed on his chart what has happened in the past and what might be required in the future. Certainly the utility systems are interested in paying the commercial value of this and participating in some of the front end costs. The vendors certainly have a role, and we feel, as Dr. Agnew showed in his chart, that there is a place for the Department of Energy.

I think if we all work together and share the costs, share the risks, that we can bring this technology to the forefront which would certainly be helpful in contributing to this country's energy needs.

I guess my last comment would be that it is almost a crime that this country with its resources of uranium, technology, coal, oil shale, has to depend on other parts of the world to supply it, when we really could do it ourselves. I think we all feel that is the bottom line thing and we are going to work very diligently to achieve this.

I thank you for your time. It has been a pleasure to be here.

[The prepared statement of Mr. Walker follows:]

STATEMENT SUBMITTED FOR THE RECORD

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

FY 1982 DOE AUTHORIZATION
HIGH-TEMPERATURE GAS-COOLED REACTOR PROGRAM

RICHARD F. WALKER
PRESIDENT OF PUBLIC SERVICE COMPANY OF COLORADO
AND
CHAIRMAN OF GAS-COOLED REACTOR ASSOCIATES

FEBRUARY 26, 1981

Madam Chairman and Members of the Subcommittee, my name is Richard F. Walker, and I am President of Public Service Company of Colorado. As Chairman of Gas-Cooled Reactor Associates (GCRA), I appreciate the opportunity to appear before you today in connection with the Department of Energy's FY 1982 Budget Authorization request for the High-Temperature Gas-Cooled Reactor (HTGR) Program.

The utility industry has a long history of support for the development and commercialization of the HTGR. Through participation in various organizations that have provided technical guidance and financial support, utilities have spent approximately $200 million on the HTGR. At the present time, utility interest and support for the HTGR Program are represented through GCRA, a Utility/User organization that was established in February 1978. GCRA has grown to represent over 25% of the installed generation capacity in the U.S. In addition, GCRA utilities represent approximately 25% of the on-line nuclear capacity and about 40% of the capacity currently under construction. This background of nuclear experience provides GCRA with a sound base for evaluating and comparing the characteristics of the HTGR as an alternative nuclear energy source. GCRA's role in the HTGR Program is responsive to the institutional need for front-end participation in technology development by the end-user of the technology. This role ensures that the investment of government and private sector resources will result in HTGR systems that will most favorably impact the U.S. energy economy. Utility financial support, through GCRA, for the HTGR Program has steadily increased to a level of about $2 million in 1981. These funds support a full-time staff that represents Utility/User interests within the programmatic activities, such as site and application studies, plus provides overall Program integration support to DOE.

To date, utility support has been instrumental in the design and construction of two HTGR facilities: the Peach Bottom prototype HTGR at Philadelphia Electric Company and the Fort St. Vrain demonstration plant which is currently operating and providing electricity for Public Service Company of Colorado. Since 1978, Fort St. Vrain has generated over 1.8 billion KWhs. With a design rating of 330 MWe, the plant has successfully operated for sustained periods of time near 70% power, while operating experience has been thoroughly evaluated by the Nuclear Regulatory Commission. We believe all outstanding questions have been answered and are awaiting word at this time for NRC approval to operate at full power.

Fort St. Vrain has provided critical confirmation and demonstration of many key HTGR concepts. Significant is the HTGR's excellent fuel performance and the resulting low radiation exposure to plant personnel. There has been excellent correlation between predicted fuel performance and observed data. Other major contributions of Fort St. Vrain have been in the areas of core physics confirmation, plant control and response, and plant performance at high temperatures. Plant operating experience to date has demonstrated predictable, easily managed performance even during extreme modes of operation, including temporary loss of forced cooling. The high core heat capacity has shown temperature transients to be slow, predictable, and easily controlled. Fort St. Vrain has also demonstrated high-performance and high-temperature capabilities. Operation to date has achieved 1400°F primary loop and 1000°F steam temperatures--the highest of any nuclear plant in the U.S. Public Service Company of Colorado is pleased to be playing a key role in the development and demonstration of the HTGR concept.

GCRA's constituency also includes potential industrial process heat users who are interested in employing the HTGR in energy-intensive industries such as petroleum refining, chemicals, and metals as well as the emerging synfuel industries. A Process Heat Advisory Committee has been established within GCRA to provide a forum for process heat users to interact with utilities and provide input and support to the HTGR Program.

Vendor/supplier support for the HTGR Program was initiated through the General Atomic Company (GA), which is jointly owned by the Gulf and Royal Dutch Shell Oil Companies. The private investment by GA in excess of $700 million has contributed to the Peach Bottom prototype HTGR and to the Fort St. Vrain HTGR demonstration plant as well as to the technology embodied in the current HTGR designs. More recently, the General Electric Company (GE) has become an active participant and supporter of the HTGR Program. Primary interest to date has been directed toward the process heat/cogeneration applications and the supporting materials technology development. Other key industrial entities that are involved in and support the HTGR Program include: Bechtel National, Inc., Combustion Engineering, United Engineers and Constructors, and United Technologies Inc. This broad cross section of industrial participation and support offers the potential to provide the full design and manufacturing capability to deploy HTGR systems. As sound and stable support is established within the government and Utility/User projects are identified, the natural competitive forces will merge to establish a viable commercial infrastructure for supplying the HTGR.

Another important area of Program support comes from international efforts aimed at developing the HTGR technology. The most active efforts are under way in the Federal Republic of Germany (FRG), Japan, and Switzerland. Of the foreign programs, the program in the FRG is the largest and most experienced. Since 1960 the FRG has invested approximately $1.5 billion in HTGR development. The current emphasis of the German program is the completion of a 300-MWe HTGR-Steam Cycle demonstration plant, which is expected to begin operation in 1984. At the present, the German utilities in cooperation with the German coal and gas companies are investigating a follow-on HTGR-Steam Cycle/Cogeneration project in conjunction with a coal gasification facility. In support of the overall U.S./German cooperation on HTGR technology development, a cooperative agreement between GCRA and other German utilities has been developed. Signing of this agreement is projected during the spring of 1981.

As presented in our testimony before this Committee last year, GCRA, in cooperation with all Program participants, has been under way with a comprehensive effort to identify an HTGR Lead Project. During 1980, a detailed evaluation of the Lead Project candidates has been conducted that has served to establish a consensus on the status and merits of the technical, economic, and market characteristics of various HTGR systems. The Lead Project evaluation effort has also served to better focus the ongoing technology development programs supported by DOE. I have with me copies of the detailed reports on each Lead Project option that have been issued to members of the Subcommittee staff. Through the Lead Project evaluation effort, the HTGR-Steam Cycle/Cogeneration (SC/C) system has been identifed by the Program participants as the primary Lead Project system for the following key reasons:

- The technical feasibility of the system is assured through the Fort St. Vrain demonstration plant plus long-standing design experience.

- Relative to the other Lead Project options, the HTGR-SC/C system requires the fewest resources, involves the fewest technical risks, and can be deployed on the earliest schedule. Accordingly, this option warrants the greatest private sector financial support.

- The HTGR-SC/C system can serve a large potential market that ranges from baseload electricity to industrial process steam. In particular, the system is ideally suited for cogeneration with central, baseloaded industrial applications such as petroleum refining, enhanced oil recovery, and synfuels.

- The development of the HTGR-SC/C system provides a large fraction of the technology required for the more advanced HTGR systems. Further, deployment of the HTGR-SC/C system advances the industrial infrastructure that assures access to the advanced HTGR systems.

Because of these factors, we feel strongly that the HTGR-SC/C system merits a high priority for government support as the HTGR Lead Project. Upon confirmation of the licensing and economic performance of the Lead Project, commercial follow-on systems may be deployed.

An attractive feature of the HTGR technology is the evolutionary applications for broadened energy markets. For example, used in conjunction with molten salt as the heat transfer medium, the HTGR-SC/C evolves into a system which has the ability to store and transport heat over distances in the range of 50 miles, making it ideally suitable for distributed and/or load-following cogeneration applications. This system is referred to as the HTGR-Sensible Energy Transmission and Storage (HTGR-SETS).

A more advanced concept, the HTGR-Reformer (HTGR-R) system provides heat storage and transportation over even longer distances. In the HTGR-R application, a portion of the reactor thermal energy is converted to a storable/transportable energy form through the use of a highly endothermic, reversible chemical reaction whereby methane and water are combined in the presence of a catalyst to form a synthesis gas of hydrogen and carbon monoxide. The balance of the reactor thermal energy is used for base load electricity generation through the conventional steam cycle. In a closed cycle application, the chemical energy is transported to remote locations utilizing the Thermochemical Pipeline (TCP) and converted to thermal energy through an exothermic methanation reaction providing delivered heat in the range of 600°C/1100°F. Through the TCP, the HTGR can serve dispersed industrial customers over a range of 200 miles. In open-cycle applications, the HTGR-R can be directly coupled to processes which utilize large quantities of hydrogen and carbon monoxide such as the ammonia and methanol industries. Because peak reforming temperatures in excess of 1300°F are required to achieve suitable conversion efficiences, the HTGR is uniquely capable of supplying these requirements. Furthermore, all of the process heat application versions (HTGR-SC/C, HTGR-SETS and HTGR-R) are readily adaptable to synfuel production and enhanced oil recovery applications.

Through an HTGR-SC/C Lead Project, the industrial infrastructure would be established that would be capable of deploying commercial HTGR systems by the turn of the century for the generation of electricity and/or process steam. Given the commercial deployment of the HTGR-SC/C system, the development of other HTGR system concepts can be readily achieved. In addition to HTGR-SETS and HTGR-R for process heat/cogeneration applications, access to the HTGR-Gas Turbine (HTGR-GT) for efficient ($\sim$40%) electricity generation with dry cooling can be pursued as cooling water scarcity becomes a severe problem. Alternatively, the HTGR-GT may be coupled with bottoming power cycles that achieve efficiencies in the range of 47% or with cogeneration applications that require low temperatures such as district heating. In fact, combining the LMFBR fuel technology and the HTGR-SC/C technology would provide eventual access to an alternate breeder concept--the Gas-Cooled Fast Breeder Reactor (GCFR).

Clearly then, the HTGR system is an energy option that has the multi-application and evolutionary flexibility which can adapt to many market requirements and resource concerns in the energy supply picture. Furthermore, the safety and environmental impact features of the HTGR provide added margin for enhancing its economic life. These features result in minimal reliance on engineered safety systems, greater siting flexibility, and added plant investment protection.

In support of the efforts to establish a Lead Project, GCRA has undertaken efforts to identify and develop candidate Lead Utilities that would build and operate the HTGR Lead Plant. To date, six utilities have expressed genuine interest in becoming the Lead Utility. Interests range from electricity generation at Florida Power and Light Company to process heat/cogeneration applications at Public Service Electric and Gas Company. Studies are ongoing to evaluate specific sites and applications, which are oriented toward establishing a Lead Project.

Regarding the cost-sharing arrangements for the Lead Project, it has been GCRA's consistent intent that the Lead Utility will finance the construction of the Lead Plant to the extent of its commercial value. In addition, the utilities through GCRA and EPRI will support a share of front-end costs associated with the Lead Project. Vendor/supplier support for the Lead Project is expected through an industrial team that will provide the design and manufacturing capabilities required for the Project. It is expected that the vendor/supplier team would share in the Lead Project risks through fixed/incentive prices on the plant components and fuel supply, and provide a broadened vendor/supplier infrastructure for subsequent HTGR commercial plants. Government support is required for the front-end design and development of nuclear systems and components, fuel cycle development and demonstration, and a share of the Lead Project costs and risks over and above the Project's commercial value.

Regarding government support for Fiscal 1982, GCRA urges the House Subcommittee on Energy Research and Production to support the ongoing efforts to establish a National HTGR Program and Lead Project. In particular, stable government support is required to complete Program definition activities and to engender a Lead Project commitment by the private sector. The near-term Program should provide the information required for such a decision with emphasis on the design and development activities required for a HTGR-SC/C Lead Project. Additional design and development should be included to support advanced follow-on systems. A target schedule for the HTGR-SC/C Lead Project has been developed that leads to a Project Authorization in 1984 and to plant startup in 1994. A DOE funding level of $55 million in FY 1982 is required to support this schedule and continuing development of advanced versions of the HTGR. This level of funding, along with Project support within the Government, will be invaluable for nurturing aggressive financial support within the Utilities/Users. Further, it is recommended that the HTGR Spent Fuel Treatment Program be continued at a funding level of $5.0 million.

The Utilities/Users of Gas-Cooled Reactor Associates believe that the HTGR offers significant advantages to the Utility/User industry and the Nation as a whole. Accordingly, we urge that a National HTGR Program be established that supports an aggressive Lead Project.

Madam Chairman, that concludes my prepared statement. Thank you for the opportunity to present the utility viewpoint to your Subcommittee. I would be pleased to answer any questions.

Mrs. BOUQUARD. Thank you very much, Mr. Walker.

Mr. WALKER. Dr. Uhrig will take over.

Mrs. BOUQUARD. Please proceed, Dr. Uhrig.

Dr. UHRIG. I am Dr. Robert E. Uhrig. I am Vice President for Advanced Systems and Technology for Florida Power Light Co.

We are a major investor-owned utility serving about 2.2 million customers or about 5 million people in southern and eastern Florida. We operate three nuclear plants—Turkey Point 3, Turkey Point 4, St. Lucie 1 and have a fourth plant under construction, St. Lucie 2, for operation in mid-1983. We, of course, are members of the Gas-Cooled Reactor Associates.

A utility decision to build a particular type of plant at a particular location is a complicated process involving many variables including, but not limited to the five I have listed here:

The need for new generating capacity;

The characteristics of the reactor powerplant;

The location of the site and its suitability for that particular type of plant;

The approval of the appropriate regulatory agencies; and, of course,

The financial ability to build that plant.

We believe that we have a combination of circumstances that favor the high temperature gas-cooled reactor; and, therefore, make us a candidate for the lead HTGR plant.

We will have the need for the capacity in the time frame that the HTGR could be developed. About two-thirds of our electrical energy use is concentrated in three southeast counties—Dade, Broward, and Palm Beach. Because of this isolation from other power generation in the State and in the Nation, we need our new generating capacity located in the southeastern part of the State, which is a very environmentally sensitive area.

We believe the HTGR, with its high-efficiency and lower-cooling requirements, with its lower-power density, with its high thermal capacity, its long thermal time constant, and its inherent safety characteristics, make it a prime candidate for our system.

This year, Florida Power & Light will spend a quarter of a million dollars of its own money on the support of the HTGR concept and the associated site studies specific to our system.

There are many other utilities who have shown interest in the HTGR through membership in the Gas-Cooled Reactor Associates. In particular, six utilities, including ourselves, have indicated interests as candidates for the lead plant.

As a group, we support the time schedule developed by the Gas-Cooled Reactor Associates, which calls for the selection of the lead utility in mid-1982, and support the concept of cost-sharing whereby the lead utility would pay for the commercial value of the plant. However, before any such commitment can be made, a base of sound Government support is needed to complete the design and licensing activies; and, accordingly, we add our support to the recommended program.

We believe that the high-temperature gas-cooled reactor can and should plan an important role in meeting this Nation's energy needs. We urge that the Nation get on with it.

Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much.

It is always good to hear from Mr. Richards. We welcome you to our subcommittee here today.

Mr. RICHARDS. I am very pleased to be here, Madam Chairman.

My name is Robert B. Richards. I am the general manager of the Advanced Reactor Systems Department of the General Electric Co. The charter of our department does include the execution of those company activities associated with the HTGR.

This is the second year we have testified before the Congress on behalf of the HTGR. I thought it might be interesting, and we will do this separately in the record, to also introduce the testimony that we did provide last year.

Once again, we will remind everyone that the General Electric interest in the use of the HTGR is one that extends from our interest in its future application for high temperature process the heat. HTGR is unique in this respect.

As you know, GE is already involved very heavily in the generation of electricity with its light-water reactor business, and we are participating extensively in the—hopefully—to be rejuvenated—liquid metal breeder business.

Our interest in the HTGR is primarily associated with its potential application for process heat.

We agree with Dr. Agnew's views on the capability of the HTGR to provide high-temperature processed heat and process heating. Over the last several years, along with General Atomic and the Gas-Cooled Reactor Associates, we have been looking at such applications that might prove attractive in the future development of this potential energy source.

We also feel that something must be done to provide alternate energy supplies that can address what we call a portable fuel problem, in today's economy. And we must utilize both coal, and nuclear power to this end. The need for developing these resources is clear.

Nuclear energy in the form of certain HTGR applications has the potential for reducing the use of oil for load following electricity production. With the light water reactor industry also in place followed by the breeder as an almost never ending renewable resource for both the LWR and the HTGR, we believe these options provide electricity for the forseeable future without the need for liquid fossil fuels.

However, much of the energy problem we have in the country is of a nonelectrical nature—transportation and industrial processed heat uses, for example. We have currently under way national programs to convert coal, oil shale, and so forth, to fluid fuels to satisfy these needs. Coal conversion will require process temperatures above those available from the other types of nuclear reactors available today. Also, a source of hydrogen is required which is, generated with high temperature process heat.

So we conclude that a high-temperature nuclear heat source, such as a gas-cooled reactor, when coupled with appropriate advanced process technology, would appear to have the unique nuclear capability to meet the need of both high temperature and hydrogen production.

One other thing we might mention concerning coal liquefaction and gasification processes. The heat source can be provided by coal. However, by high temperature helium from an HTGR as a process heat source, we can save the burning of a substantial amount of coal, thus alleviating the environmental problem associated with the buildup of carbon dioxide in the atmosphere.

During the last year, fiscal 1980-81, we have been participating in and focusing our attention on a review of many of the possible future process heat applications. These studies are on defining what process temperatures are going to be required and what research and development will be needed for both high temperature materials and components. Concurrently we also have a very strong materials development program under way in our laboratories.

We have identified over the past year several areas of R. &. D that should go on to establish what these processed heat plant systems might look like.

We have done engineering to establish system design parameters. We are identifying both what the design, development and testing of the critical nuclear heat source components would be for such high temperature applications and, as I mentioned earlier the materials development that we would be working on throughout the program.

We also are looking at the safety and licensing aspects of such a nuclear process plant.

Thus far over the last several years, our studies have convinced us that, if an immaginative and careful research and development program is carried out, then we can look forward someday to the application of these high temperatures to satisfy much of our critical energy requirements.

We endorse the recommendation made earlier that the program should continue throughout the next several years to focus on the establishment of eventual projects.

You heard earlier about the so-called HTGR steam cogeneration project. It has been identified as a study that will serve to lead and guide the development of the HTRG.

We would also hope, because of our interest in very high temperature applications, that the program will be adjusted and adapted and include, the advanced technology development that will be identified from our studies—advanced high temperatuare materials and components requird for some of these very high temperature applications.

We would hope also that the program would continue to focus its attention on the critical development areas necessary to establish the feasibility of achieving these very high temperatures.

We believe, as mentioned earlier, that the fiscal 1982 levels of funding should be on the order of $55 million, as was mentioned earlier another $5 million is also needed to develop the fuel cycle and, fuel reprocessing.

With that I will say that we trust the committee can come up with a positive recommendation to keep this most important program going.

Thank you, Madam Chairman.

[The prepared statement of Mr. Richards follows:]

# TESTIMONY OF

# GENERAL ELECTRIC COMPANY

BEFORE THE

ENERGY RESEARCH AND PRODUCTION SUBCOMMITTEE OF THE

SCIENCE AND TECHNOLOGY COMMITTEE OF THE

HOUSE OF REPRESENTATIVES

FEBRUARY 26, 1981

My name is Robert B. Richards. I am the General Manager of the Advanced Reactor Systems Department of the General Electric Company. My Department's charter includes those company activities in the field of the High Temperature Gas Reactor, among other activities. It is a pleasure to appear before this Subcommittee to describe our interests in this potentially large energy source, and our recommendations for the direction of the nation's program for the HTGR.

This is the second year we have testified before the Congress on behalf of the HTGR, although our involvement in this field goes back almost a decade. During this time, our involvement and our interest in the HTGR as a potential substitute for petroleum have continued to grow.

The following program status report and program recommendations reflect the progress which has been made in this area since we last submitted testimony to you, as well as our recommendations with respect to program direction from this point forward.

The future adequacy of our national domestic energy supply depends on proper management of our fossil and nuclear fuel resources. Based upon current predictions of domestic portable fluid fuel resources, the need for increased dependence on coal and nuclear resources appears clear.

Nuclear energy has the demonstrated potential -- as does coal -- of alleviating the use of oil for electrical production. The existing light water reactor industry is in place specifically for this purpose in the near term and the national fast breeder reactor program is underway to assure that this nuclear option remains economically viable for the foreseeable future.

However, a substantial portion of our fluid fuels energy usage is for non-electrical applications -- transportation and industrial process heat. Currently research, development and demonstration programs are underway to explore ways to convert coal and oil shale to fluid fuels. Coal conversion normally requires process temperatures above those available from light water reactors and a source of hydrogen to perform the liquefaction or gasification step. A high temperature nuclear heat source, such as a gas cooled reactor, when coupled with appropriate advanced process technology, appears to have the unique nuclear capability of meeting the need for both high temperature and hydrogen production.

Coal liquefaction and gasification applications look technically viable and appear to have promise of being economically competitive. Shale oil recovery and refining applications may offer even more promise as a future portable fluid fuel resource. A high temperature gas cooled reactor coupled to a reformer has the potential of providing both the process heat and hydrogen necessary to convert coal to methanol and oil shale to a refined product with a fossil fuel savings (coal or shale oil) of up to 40%. In addition, the nuclear heat source can substitute directly for oil, methane and coal in many industrial process heat applications, saving the atmospheric burning of the coal, and the attendant $CO_2$ buildup, which would otherwise occur. This is seen by many to have potentially profound benefits to the environment.

In summary, we view the HTGR's importance to be that of a nuclear heat source for synthetic fuels and industrial process heat production.

This requires process heat temperatures 150 - 200°C higher than the design temperature of Ft. St. Vrain and so demands research and development in the materials and components of both the reactor and the reformer used for these processes to prove that this capability can indeed be achieved within an appropriate period of time.

Domestic and international programs (primarily in Germany and Japan) have been underway during the past several years to develop the technology for such a nuclear heat source. In the U. S., the technology development is at the conceptual stage, with materials development programs underway to qualify the materials needed for a 30 - 40 year nuclear plant life.

During FY-1980 and 1981 the U. S. program in which the General Electric Company is participating has focused on a systematic review of the applications for process heat and liquid fuels production for a gas cooled reactor powered system. These studies have also focused on defining the research and development (R & D) required to bring each application to commercial demonstration. The R & D required can be separated into the following major categories:

o Engineering required to establish system design parameters and specifications for each major part of the system. This includes the nuclear heat source and the process heat or fluid fuels production plants powered by the nuclear heat source.

o Design, development and testing of the critical nuclear heat source components for these high temperature applications. The most important of these are: the support and radial restraint for the reactor core, the fuel and fuel handling system, the heat transport components (ducts, circulators, heat exchangers) and the thermal barrier and liner for the reactor vessel.

o Design development and testing of components in the process heat or fluid fuels production plant. The most important of these are: the reformer (where the heat from the reactor is used to produce hydrogen or process gas which can be used as a transportable fuel) and the methanators, which convert the process gas into heat and recyclable products.

o Research and development with licensing of nuclear powered process heat or fluid fuels production plant systems. The most important are: establishment or criteria for seismic design, criteria for handling toxic or potentially explosive gases ($CO$, $H_2$, $CH_4$), plant inspection requirements, and data on materials behavior.

Design and development work completed to date has indicated that the commercial requirements can be satisfied if the needed development programs are completed.

During FY - 82 it is recommended that the program focus continue to be toward the definition of the specification and design for a process heat or fluid fuels production plant and on those R & D programs critical to a near term project commitment in the FY - 84-85 time frame and the operating prototype of an integrated synthetic fuel and process heat producing plant by the year 2000. In order to meet this schedule for a project commitment in FY - 84-85 a funding level of $55 million per year is estimated to be required in FY - 82 and 83.

We believe the options provided by such a system warrant the continuation of a national development program.

Mrs. BOUQUARD. Thank you very much.

As we said earlier, I think it is necessary to realize that a better Government does not buy reactors, that utilities do. It is certainly feasible for utilities. This is certainly the direction we should move in our efforts to make this country more energy independent.

I would like to direct a question to Mr. Walker and to Mr. Uhrig in terms of our funding.

Is it possible that the lead plant project to move ahead at a level of $40 million in fiscal year 1982 and would a line item at this funding level lead to commitment by a utility so it would be going in with future Federal funding? If we could do this, it seems to me that there would be a real project withdrawal of necessary Federal support with that level of funding with the line item that we could move ahead.

Dr. UHRIG. I think any reduction would probably involve some out of the schedule, but I don't think it would be a significant deterrent in terms of the eventual commitment here because there would be apparent advantages associated with this particular design that are attractive.

I think it might have some effect on the time scale that you see presented before you.

Mrs. BOUQUARD. Stretched out on the programs?

Dr. UHRIG. Yes.

Mrs. BOUQUARD. But do you a feel line item would give further stability to the cause?

Dr. UHRIG. I am not familiar enough with the process of a line item but, as I understand it; yes. If I understand your question, I think the answer is, yes.

Mr. WALKER. I might supplement this, Madam Chairwoman.

The possibility of moving up the site selection date is probably not doable because the six utilities are just in the process of starting their studies on site and that sort of thing.

I would agree with Dr. Uhrig that, if the funding were 40 instead of 55, that means you do not get quite as much done in the design and development part and would stretch the schedule, and it could theoretically affect when you would establish a lead utility.

Obviously, when you don't have as much money, you probably are going to take more time.

Mrs. **Bouquard**. For the benefit of two of our new members, I know that Mr. Volkmer is especially interested in industrial participation in financing these projects.

I do think it is commendable that it has been proposed to pay the cost of the plants, to provide this capital with DOE providing funding for the components R. & D. and engineering. This is certainly a major consideration as we consider marking up our bill for fiscal year 1982.

Also, I would like, perhaps anyone that may choose, for our two members, to go into some basic details of the safety features of our HTGR.

Mr. **Walker**. Since my utility runs the reactor, I will speak to it in general. If the members have more specific questions, I would be glad to address them.

I would agree with Dr. Agnew that, from a public safety standpoint, all reactor systems, based on the record, show that they are very, very safe when you look at the risk to the public.

Dr. Agnew made a good point that what we are concerned about is not only safety, but the protection of the investment that all of us will have in these plants and have already, and certainly a "forgiving" design as he indicated, gives you a little more comfort in that area.

As I mentioned earlier very briefly, the HTGR does result in lower radiation levels for the workers; lower buildup of fission products in our system; lower amounts of low-level waste that is accumulated and amounts that are released into the atmosphere are, an order of magnitude lower than other plants.

These are inherent things. Even though they do not make too much difference to the safety of the public, It does give us a lot of comfort.

I guess as an operating utility, our main concern is being able to maintain this equipment over the life of the plant. Lower radiation levels in the plant and on the equipment certainly means that it is easier to maintain. It takes less manpower, and there is less exposure to workers.

Because of the inherent safety aspect features of this, we have more time in case there would be a loss of coolant and these types of things. I think that has been addressed before. We don't necessarily brag about it. It is just inherent there, and we are glad that we have it.

Mrs. **Bouquard**. Do you think the public will make a distinction between the HTGR's and reactors and there will be greater public acceptance with the HTGR?

Mr. **Walker**. I guess I would like to say yes; but I think to the general public nuclear power is nuclear power. There is going to be a certain element of the general public that has a fear no matter what kind of a reactor you have.

You are going to have an element out there that we are going to have to live with and cope with that nuclear power is just bad.

Mrs. **Bouquard**. Mr. Richards, would you elaborate just a little bit. You all had such a fine testimony. There isn't a lot more that we can add at this point. Just elaborate on the HTGR applications and synfuels and what is the interest in the industry in this direction?

Mr. **Richards**. We look at the application of the HTGR to the manufacture of synfuels. One such application that we have studied, which was mentioned in last year's testimony, is called steam-methane reforming to convert the reactor process heat to a stored, ambient temperature thermochemical energy form capable of being transported over long distances. This nuclear-reformer unit will take mixtures of methane and water and, at high temperatures, convert them into a carbon monoxide and hydrogen mixture that can be transported to a pipeline from a reactor to some site. There it can be reconverted, releasing both process energy and the original methane. In this way the heat that was put in can be recovered very effectively at diverse industrial sites for industrial applications, synfuel production, and so forth. The converter is a device called a methanator, in which CO and hydrogen can release their stored energy in the form of heat while being recombined to water and methane, which then can be taken back to the reactor, and again be recycled with no net loss of fossil fuel to the environment.

This is one of the applications we have looked at, and it is very attractive because as I have indicated, you can site the reactor some distance from the processed heat applications for which it would be used.

Mrs. **Bouquard**. Do you think that the HTGR project line item would encourage the NRC to take the licensing activity more seriously, Mr. Walker?

Mr. **Walker**. I think that it probably would. NRC, of course, is very busy with lots of things these days, and I am sure they have their own staff problems.

They did have money appropriated last year, as I recall, to do work and did not spend some of it. I can understand why. It was not the highest priority thing they had to do, so they didn't get around to do that.

I think that a signal from DOE that this kind of thing is going forward would also be a key to get NRC on with the work that they should do. Hopefully, NRC will have money again this year as they had last year and, hopefully, this year they would spend some if it.

So I think that a line item would be a very positive indication to the Regulatory Commission, to the extent that I can speak for them.

Mrs. **Bouquard**. Dr. Agnew.

Mr. **Agnew**. Madam Chairman, about 3 months ago, I addressed a chapter of Sigma XI, which is the scientific organization in the various physical sciences, primarily. At that meeting, the composition of the audience—and about 200 in the audience—was primarily people who work for the Department of Energy, the NRC, and the reactor licensing people.

When I finished my remarks, I talked a little bit about the HTGR and its advantages, as I see it, coming as I say from a more defense oriented background in nuclear physics, and there were at least six people in that audience who afterwards, in the questioning period say they really wished we would get on with the HTGR because, from their perspective, in the licensing business, it would make their job so much more easy because they appreciate the "forgiving" design.

I think the rules under which Public Service of Colorado operates is indicative of the advantages which the NRC people—the working people—really understand and appreciate, and the reactor-licensing people appreciate this "forgiving" nature—this time that you have; and, from their perspective, there is no question in my mind, and I did refer to Commissioner Hendrie's testimony last year where he advocated this technology.

Mrs. **BOUQUARD**. I just want to inform you that the reporters are having a hard time picking up on all of you. So, if you all would speak up a little bit more, I think it would be beneficial to all of us.

Mr. Lujan?

Mr. **LUJAN**. Thank you, Madam Chairman.

Harold has already convinced me that the HTGR is the best. [Laughter.]

So I will go from there. Mr. Walker, you are the only utility using the gas reactor; is that true?

Mr. **WALKER**. Yes; that is correct, at the present time.

Mr. **LUJAN**. What other kinds—coal, I assume, gas, oil.

Mr. **WALKER**. Yes; for the rest of our generation, we have a small amount of hydroelectric, and then the rest of our stations are fossil stations. They burn a mixture of coal and gas.

Mr. **LUJAN**. This is the only nuclear plant?

Mr. **WALKER**. This is the only nuclear plant that we have; yes, sir.

Mr. **LUJAN**. What is your experience at Fort St. Vrain since you took it over in comparison to the other plants down time?

Mr. **WALKER**. As I indicated, we took the plant over in 1979. I did indicate that we have had some problems with some of the auxiliary systems that caused problems that would trip the plant off the line. There was also some problem in some of the auxiliary systems which I won't get into in a technical nature, but it has taken longer to get correct.

We have also had to continue to do some design modifications that come out of rules at NRC on seismic supports, and this kind of thing. These have caused some down time.

Mr. **LUJAN**. This is not because of the operation. That is because of the rules at NRC?

Mr. **WALKER**. Both NRC rules and the design, to some extent. Also, we have had one refueling. In April, we will come down for the second refueling of the plant.

Later this year we will also make some major changes in some of the auxiliary systems which will require us to be off for probably 3 or 4 months.

Mr. **LUJAN**. Generally, are you satisfied with the overall operation?

Mr. **Walker.** Yes; when it runs, it is a beautiful plant. As I say, through January and February, it has run almost around the clock at around the 200 megawatt level. It is a good plant to operate.

Mr. **Lujan.** It is operating at 200 megawatt level?

Mr. **Walker.** Yes; we are limited to 70 percent of the license capacity by the NRC.

Mr. **Lujan.** How does that compare with other nuclear plants—the 70 percent?

Mr. **Walker.** Well, this was a limitation put on by the NRC, which we are hoping to be released from very shortly. We have been promised but I can't give you a definite date on that.

You were not here when I gave the earlier testimony, Mr. Lujan, but we did accept the plant from the General Atomic Co. at a rating of 200 megawatts, even though it is designed for more and we hope that it goes to more. That was the basis of our acceptance in our contractual arrangement.

Mr. **Lujan.** Do you think it will go higher?

Mr. **Walker.** It obviously will go higher than that if we run it clear up to the peg. We are confident that it will go on up. I couldn't sit here today and say that it would go clear to 330 and work perfectly.

Mr. **Lujan.** Let me follow up something else. Harold and I were at a conference in Mexico recently. One of the things that was very disturbing and not just the HTGR, but that Mexico is going to buy some 20 reactors in the next 20 years and the feeling of the Mexican officials was that we are out of the running—the United States. All United States of America is out of the running because of many different things.

At lunch, I asked Dr. Costa who is the head of their Atomic Energy Agency why they didn't buy any HTGRs. The big reason was there is not an operating one in 600 megawatts, and that is about what they want.

His reply was operate one and, when we get it operating, then they will buy them.

Well, that is the problem. General Atomic cannot go out and just build one. I was thinking about how we could do it, and I was thinking about maybe through our power marketing agencies somehow—TVA or some of those.

It is interesting—and I wasn't in for your testimony, Dr. Uhrig—that those utilities in the Southeast would be willing to pay for the construction or some participation from the Federal Government.

Give me a rundown of what you are talking about, what you think it would cost, how much the utilities would bear of that cost, how much the Federal Government would and what sorts of things would the Federal Government be paying for—like, if you came to offer a deal to DOE right now—we want to go into this type of plant and this is what we would like and this is how we would like to put it all together.

**Voices.** It is already in the transcript.

Mr. **Lujan.** All right. Then I will read that testimony.

Mr. **Walker.** There is a good chart here.

Mr. **Lujan.** All right. I will go into that later on.

It seems like the testimony, at least from what I gather, is directed to the industrial uses of the high temperatures that an

HTGR can achieve, and you can use that heat for industrial processes.

Is it cost effective just to generate electricity for the HTGR without going into these other areas. In other words, would this be a plus?

Mr. WALKER. Yes, I believe it is. Of course, the lead project that we would start out with would be a steam cycle which would generate electricity. Depending on where it might be located, some of the steam could be used in a cogeneration aspect, and that is after our last year's study of the four project options. The steam cycle which makes the electricity with the possibility of steam cogeneration is the lead project which should go forward.

The process heat can build on this technology, and it would be a plus that you would get after you had developed the steam cycle/cogeneration plant. It would presumably come on later because there is less risk involved in the steam cycle than in the heat process cycle which requires higher temperatures. In a nutshell, that is why we chose the steam cycle as the lead project.

Mr. LUJAN. You are asking for $40 million this year?

Mr. WALKER. $55 million is the figure that we are requesting.

Mr. LUJAN. Would that be sufficient for the needs of the Southeastern region; Dr. Uhrig?

Dr. UHRIG. This would be the amount that's needed in the development of the program here. Our participation here is potentially one of the lead candidates where, in the overall project, we would expect to pay for the commercial value of the plant; for example the first-of-the-kind cost, and the development cost. The R. & D. cost would be basically borne by the Government. Of course, the R. & D. comes at the front end, unfortunately.

Mr. LUJAN. I would like, if we can, to get to this sort of thing that you say was in the chart.

Mr. AGNEW. Fine. It is in the written testimony, too.

Mr. LUJAN. Thank you very much, Madam Chairman.

Mrs. BOUQUARD. Thank you, Mr. Lujan.

Mr. Volkmer?

Mr. VOLKMER. Yes. Thank you, Madam Chairman.

I have been following on the funds. You know, we are up here in a big crunch. We are going to balance the budget, but we don't believe it. [Laughter.]

To be honest with you, I am afraid to hear some of the reasons we are not going to balance it.

What if the funds are all together cut off? What does that do to HTGR—no Federal funds at all in 1982.

Mr. WALKER. It certainly would be a very difficult situation for us, and it would be analogous to the gas-cooled fast reactor, the Helium Breeder Associates which did have funding up until last year and, of course, they got no additional funding, so they had to cut back, lay off the people. They still have their organizational structure in place. There is very little work going on in the gas-cooled fast reactor because of that. The same thing would happen to us. If there was no money whatsoever, we would have to cut back. We do have some funds of our own and we would try to keep a semblance of things going. Obviously, not very much would get done.

**Mr. Volkmer.** What would General Atomic's interest be from then on?

**Mr. Agnew.** I can't really speak for the owners, but I have a feeling that, having spent close to a billion dollars in this effort and being confronted with other areas where they could put their money in other energy activities, I think they would probably say, if we can't get cooperation with the Government in this field, they would close out the activity.

I think it would be a tremendous loss to the people of the United States. I think the programs might continue, and I think they probably would in Japan and in Germany. If we have another Three Mile Island in this country with nothing to fall back to, that is where I don't differ with Mr. Walker in the public's perception, but I think that, if one can talk to the public on factual basis and point to them that we are improving the systems and you can point to real scientific differences, you can get this large center group that is neither polarized one way or the other to be much more on the side of the nuclear systems.

**Mr. Volkmer.** What I am hearing from both utilities then, and I have not heard from Mr. Richards, but what I am hearing also from private enterprise, is that private enterprise is not prepared to go ahead in these fields.

**Mr. Agnew.** All by ourselves.

**Mr. Volkmer.** I hear it also in demonstration projects for coal. I have been hearing that in the last 2 days, also.

What I am afraid of, as the administration in many areas has projected in the energy field, is we may have a complete shutdown of energy demonstrations in this country, which is going to put us way back.

**Mr. Agnew.** I think you are absolutely right.

**Mr. Walker.** Even worse than the loss of the money, it is the signal that it sends out. You know, you can tolerate stretching money and that sort of thing; but, if it is perceived that that is the end of it—that's the death knell—why then, you are really dead in the water.

**Mr. Agnew.** If we cut back and stretch out, I think people will survive—it's different—but, if you go to zero, then I think, as Mr. Walker says, there is a signal that the United States is just not interested in nuclear energy any more.

**Mr. Volkmer.** In that area.

If we go ahead with the lead plant—let's assume that—what new is to be determined other than we have a demonstration—a full-scale plant? Other than that, what new technology can you tell me would be developed?

**Mr. Walker.** Certainly, just going up from the size of Fort St. Vrain, which is 330 to 860 megawatts electrical and, of course, using some of the things that we have learned at Fort St. Vrain on some of the systems. These have been simplified and redesigned and would be incorporated. There would certainly be some things in some of the other systems, but the scale-up is the really big thing. If something works at one size, it doesn't necessarily work at another.

**Mr. Volkmer.** In other words, what I am hearing maybe is a little bit from some people over in the present administration that demonstration plants are a lot more than just demonstration plants. It is a continuation of R. & D.; is it not?

Mr. **Walker**. Yes, it gets to be some semantics on what is research and what is demonstration.

Mr. **Volkmer**. The philosophy that I am finding in the present administration on energy is that, if technology is there, private enterprise will take it and run with it if it is feasible. I don't find that true.

Mr. **Walker**. If it is demonstrated.

Mr. **Volkmer**. They don't say if it is demonstrated.

Mr. **Walker**. Don't they?

Mr. **Volkmer**. No. They don't want demonstration.

How long is the plant life for HTGR?

Mr. **Walker**. It is generally figured at about 30 years. A normal NRC license is a 40-year license, and that time starts to run when the construction permit is obtained.

Mr. **Volkmer**. About the same period as a light water, approximately?

Mr. **Walker**. Yes, there would be no difference in that.

Mr. **Volkmer**. Thank you, Madam Chairman.

Mrs. **Bouquard**. Thank you very much, Mr. Volkmer.

Mr. Lowery?

Mr. **Lowery**. Thank you, Madam Chairman.

Dr. Agnew, I welcome you. You have spent much more time before the subcommittee than I, so it is more appropriate that you welcome me. [Laughter.]

Mr. **Lowery**. Obviously, there is a very strong commitment to this approach from this committee looking to the administration's previous budgets.

Can you outline for us what the time table would be for bringing the HTGR on line—the demonstration—both in terms of the timing, as well as the dollar commitment, under two scenarios: One, optimum, the quickest we could bring it on and, also, under what looks like the current funding of about $45 million?

Mr. **Agnew**. Mr. Lowery, I think that the program that the Gas-Cooled Reactor Associates have outlined is probably an optimum program. You might be able to shave a year off that, perhaps and maybe not. It is like a 12-year program.

Mr. **Lowery**. 1994-1995?

Mr. **Agnew**. Yes. The thing that impresses me about Fort St. Vrain and what, let's say, the people before me at GA working with the public service of Colorado have been able to do is the following:

Fort St. Vrain was started 2 years after the equivalent German program. The German program started 2 years earlier. Fort St. Vrain has run—as Mr. Walker has mentioned—the nuclear portion of the plant has worked extremely well. There have been glitches in the balance of plant which were brought about perhaps because people hurried, perhaps because more funding was very skimpy, so whereas one should have been put in some redundancy in the balance of plant and some valves and some subsystems, coupled with the fact that the rules changed and they had to sort of haywire around these things.

Nevertheless, that plant has been running now for almost 2 years.

The German equivalent—is set to run about 2 years from now, if I am correct.

So I would say it is a tribute to the American industry and American technology what we have done. I think that this kind—we call it a demonstration—but I really think it will be a plant which we will be able to replicate for the industry and for the world.

Even in the automotive industry, and as Mr. Volkmer has questioned, the automotive industry every year recalls things. They are not demonstrating autos. They have made autos for years; but, when you bring out a new product, there are certain things that, until you actually build it, you can't really determine how well it is going to perform.

Now I think based on our Peach Bottom, Fort St. Vrain, and the study that this group—these people—have devoted, we have an optimum program here. At most I think you might gain, perhaps, a year, but you have to consider there are many NRC regulations—I will call them roadblocks—that one has to go through, and it is very difficult to speed up that process.

Mr. LOWERY. At what funding level?

Mr. AGNEW. I think the funding level which has been laid out, which is on page 6 of my testimony, which is specific toward the project, is an optimum program. As I said, it would average about $26 million over the 12 years starting at that level and then decreasing. The other moneys, of course, would be necessary to continue parallel developments so that one will have the option eventually of the process heat technology.

But a great deal of work, as shown by these volumes, reformed by Mr. Walker, has gone into this program and looking ahead. I think it is a very prudent and a very cautious, conservative program which will bring into being this program and this plant in the period of about 12 years from now.

Mr. LOWERY. If I am correct in interpreting these numbers, a total of $36 and $46 million together, Dr. Agnew? Do you think that would be the ideal figure for this year instead of $45 million?

Mr. AGNEW. For 1982, the specific money on the plant is $36 million and, in 1983, it is $46 million.

Mr. LOWERY. Where do the numbers differ—the administration comes in at $45 million.

Mr. AGNEW. I don't know what the administration is coming with. The difference between, let us say, the $36 million and the $45 million, that difference is work on generic work leading to better materials. It is sort of a basic technical background which compliments the program, which one should have looking downstream.

It is not specifically fuel cycle. Fuel cycle is down here for $5 million, which is done primarily out of Oak Ridge National Laboratory.

But the difference of the $9 million has to do with better materials. It is sort of a base science program, which you should, if you have a program of this magnitude, have the people available that, when you do have problems, you have the scientists and engineers to back it up and do that work.

The barebones money required to put this project into being are those numbers listed on page 6 at the top of the program.

Mr. **Walker**. Yes. The $55 million includes some other things that have to do with the whole project. We could supply the details on what makes up the $55 million. Maybe the staff already has that.

Mr. **Agnew**. The $45 million.

Mr. **Walker**. It breaks it all down. What DOE has, I don't know. I haven't seen that. I think maybe the staff has all the breakdown on the figures.

Mr. **Lowery**. Mr. Agnew, how much of the total cost of the project would be Government funded?

Mr. **Agnew**. About one-third.

Mr. **Lowery**. At what point, would the private sector take on virtually all of the risk? What are the factors that would prohibit that? What makes this not completely marketable to the private sector?

Mr. **Agnew**. I think the problem is that the regulatory process, the uncertain climate today, the past history of the money that the private sector has put in, is that they are very reluctant, or I would say, refuse to do this by themselves.

Mr. **Lowery**. Like the $100 million invested in San Desmond.

Mr. **Agnew**. As an example.

And I think that is why it is so important that your committee essentially put this in as a line item project authorization for this plant, and then there is no question in everybody's mind what the objective is and where the focusing should be.

As I mentioned earlier, I think the program has been remiss in not focusing sooner, but essentially trying to accommodate some of the fluctuations in the winds of the Department of Energy and other Government bodies that one year wanted one thing and one year wanted another thing.

It is very difficult to turn these programs on and off and change the direction. We need to focus it. We know what the objective is, and let's get on with it.

Mr. **Lowery**. What if we took the other approach, as well, and just cleaned up some of regulatory processes, and not lessened the amount of public dollars that would necessarily be spent?

Mr. **Agnew**. For the total industry, I would certainly think that should be done, and I think these gentlemen can speak to that better than I can.

Mr. **Lowery**. It seems there is a trade-off. We are unintentionally—if not intentionally—escalating the costs of the public investment—the review process that is occurring?

Mr. **Agnew**. Well, an exact example of that was in the Peach Bottom plant. The first fuel that went into the Peach Bottom plant did not perform very well at all, but it was running. They saw what the difficulties were, and the core was replaced with fuel which then performed beautifully for the next 6 or 7 years.

Under the present rules, you could never do that. You would have to build a reactor to demonstrate it before you could build a reactor for the other purposes, and that adds also to time, also to money, and complications.

So you are absolutely right.

Mr. LOWERY. Mr. Agnew, on the timing of the HTGR program in the United States compared to the program in Europe or Japan, it looks like they are spending about four to five times what we are spending in this area. How far along are they in terms of demonstration and refinement of the technology?

Mr. AGNEW. I would say that Japan is really just starting. Their interest to date has been, of course, electrical generation but, right now, it is focusing on a small 50-megawatt unit for process heat. That is what their focus is, and they are at a level of about $25 to $30 million this year.

The German program has a two-fold objective: One for the electrical generation and the other for process heat. They are interested in high temperatures.

I should say that the Japanese were interested in 1,000° C.; whereas, we have been talking 750° C to 800° C. I now understand they have come down from that objective of 1,000 to 900, and we have the feeling it may move back to around 800 or so, 850, which is what Dr. Richards has been talking about.

I don't know why they have been delayed so long. There have been some licensing interventions. In part, I believe it could be that the technology they are pursuing is a pebble-bed concept, which is very attractive because it essentially uses continuing refueling. It works very well for very small size reactors, but there are some problems having to do with control rods and the thermal shielding when one gets to a very large size.

I think as they have gone from their small size to the large size, they have just encountered some difficult technical problems, which they have not yet been able to solve; whereas, with the graphite block system which we are using, it is very straightforward. You don't have the—I call them—fluid dynamic problems, but there are engineering problems of the control rods in their system when it gets large.

Mr. LOWERY. Are the West Germans producing power now from their gas-cooled reactors?

Mr. AGNEW. They had a very small plant operating.

Mr. MEARS. Fifteen megawatts.

Mr. AGNEW. We have research reactors around the world TRIGA reactors that are larger than that.

Mr. LOWERY. How about the Eastern block? Where are they in the development technology?

Mr. AGNEW. I simply do not know, other than presumably they have had an active program in water systems. They presumably were building a mass production facility to produce under Soviet sponsorship, of course, reactors. That seems to be lagging very much. I have heard from time to time that they are interested in high-temperature gas reactors, but I simply don't know.

Mr. Mears?

Mr. MEARS. The Russians do have an active gas reactor program with emphasis on process heat. It is in the designing and conceptual stage. There is no pilot plant yet under construction.

Mr. AGNEW. That is Mr. Dan Mears, from Gas-Cooled Reactor Associates that supplied that information.

Mr. LOWERY. I have a couple of more questions.

Mrs. BOUQUARD. We are going to have to move in about 5 more minutes. Thank you.

Mr. LOWERY. Very well.

Dr. Uhrig, did I understand you correctly in your testimony that Florida Power & Light would pay the full cost of the plant?

Dr. UHRIG. What we would expect to pay is the commercial value of the plant representing basically what it would cost if this were an "n-th" plant as opposed to being the first of a kind.

Mr. LOWERY. The Government would carry the full cost of licensing or how would that be?

Dr. UHRIG. Well, we would expect to carry the cost of licensing to the same extent that we would in any other plant. On the other hand, where there are unique licensing problems associated with this particular plant, we would expect the Government to pay the costs. This would have to be worked out.

What we are trying to do here is to arrive at an equitable situation for our customers, and our investors, while at the same time, helping along the technology so that the end result here is that our customers do not have to pay an undue share of the development of this particular technology that is going to benefit the country as a whole, as well as our own security.

Mr. LOWERY. The Government should be paying for the development cost?

Dr. UHRIG. Yes. That is the concept here.

Mr. LOWERY. What about any indemnification if it doesn't work out according to plan?

Dr. UHRIG. We really have not gotten that far in working out the details.

Mr. LOWERY. Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much, Mr. Lowery. We certainly welcome you to this committee. We see that you are going to be a very sound and very active member, and we are happy to have you.

We do want to thank you for the valuable testimony, for your input, and for your concern. It certainly meant a lot to our hearings, as we make our determinations and marking up what we hope to be in the budget, and we will put our mutual programs forward as we have expressed to you.

Our next meeting will be next Tuesday, March 3. We will at that time review the magnetic fusion program. Then we will go from there to the breeder, and then to the fuel cycles. So next week promises to be a very interesting week, as well.

We are dismissed for now. Thank you very much. The subcommittee stands adjourned.

[Whereupon, at 12:08 p.m., the subcommittee adjourned to reconvene on Tuesday, March 3, 1981.]

HBA
HELIUM BREEDER ASSOCIATES

March 20, 1981

The Honorable Marilyn L. Bouquard
Chairman
Subcommittee on Energy Research
and Production
Room 208
Cannon House Office Building
Washington, D.C. 20515

Dear Mrs. Bouquard:

Helium Breeder Associates, of which I am Chairman of the Board, would like an opportunity to present the accompanying written statement in support of the Gas-Cooled Fast Breeder Reactor to your subcommittee. This is in connection with the Authorization for funding for National Breeder Program in FY 1982.

Sincerely,

Ralph M. Davis

Ralph M. Davis
Chairman of the Board
Helium Breeder Associates

Encl.

PUGET POWER BUILDING, BELLEVUE, WASH. 98009

Thank you for the opportunity of allowing me to present testimony to your committee. I am Ralph M. Davis, Chairman of the Board of Helium Breeder Associates (HBA), and I am speaking to you ~~today~~ as a representative of approximately 74 utilities and industrial participants who are members of HBA and who have contributed significant financial support to the development of Gas-Cooled Fast Breeder technology.

The Gas-Cooled Fast Reactor (GCFR) program was terminated by the Carter Administration at the end of fiscal year 1980. We, along with the General Accounting Office, believe that this decision was premature and we urge you to reinstate this program as part of the national breeder program.

Helium Breeder Associates believes that nuclear energy is essential to the future well being of this country and that a long term role for nuclear energy in our future energy economy can be assured by a strong program to develop breeder reactors. We are pleased to see that the Reagan Administration has increased the breeder budget significantly. However, that budget is all related to the Liquid Metal Fast Breeder Reactor program and as such lacks the diversity of supply which is the hallmark of the American System. We concur with the recommendation to the Congress in the GAO report "U S Fast Breeder Reactor Programs Needs Direction"(1) that "A commitment to a long term nuclear option should include continued support for the Gas-Cooled Fast Breeder Reactor Program since it is currently the only real nuclear alternative to the LMFBR technology".

(1) EMD 80-81 September 22, 1980.

What if the LMFBR fails for technological, institutional or economic reasons to fulfill its objectives? Without the GCFR the country has no long-term nuclear alternative. We are not interested in slowing down the mainline LMFBR Program. However, we feel that it would be only prudent to spend a small fraction of the national breeder program funds on the GCFR to enhance the probability of ultimate success and to provide technical insurance.

Although most of the world wide effort has gone into the LMFBR, a complementary effort toward a GCFR has made significant progress on an international scale. The GCFR is an advanced breeder reactor which uses helium for cooling leading to a number of potential advantages. They include:

(1) The transparency of helium to neutrons which inherently results in a very high breeding ratio.

(2) An apparent energy cost lower than any other power reactor as indicated in economic studies done by a leading architect-engineering company for DOE.(2)

(3) Considerable easing of operating and maintenance problems because helium is a transparent and chemically inert gas.

Recognizing that the cost of development of any brand new reactor concept is very high the GCFR has been designed to make maximum use of helium system and component technology which has been demonstrated in the Fort St. Vrain Gas Cooled Reactor and fuel and physics technology which is being developed under the LMFBR program, both in this country and elsewhere. Hence the program is incremental in nature and the estimated cost of its development much less than that for a completely new concept. In fact, a funding level of 5% to 10% of the national breeder program would assure technical advancement of the program and the continuing interest of the utility industry.

(2) C004954-1 "Final Report and Initial Update of the Energy Economic Data Base (EEDB) Program Phase I" prepared for the Department of Energy by United Engineers and Constructors, Inc. December 1979.

The utility industry initiated support for the GCFR in 1964 following several years of private development by General Atomic Company. The utility interest stems from the desire to assure themselves of a long term source of fissionable material, to achieve the potential advantages of gas cooling, and to provide diversity of concept. In spite of the lack of government funding in FY1981, HBA has continued as a corporate entity and has not to date lost any members.

The AEC and its successor organizations, also supported the programs starting in FY1964 initially in the area of fuel development and later more broadly.

In Europe, two efforts evolved. One was an international industry group, Gas Breeder Reactor Associates (GBRA), which worked closely with the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD). The other consisted of cooperative programs among General Atomic, Kraftwerk Union and the German Nuclear Research Centers at Julich and Karlsruhe and between General Atomic and the Swiss Federal Institute for Reactor Research.

Exchange of information among all parties was extensive so that there was no duplication of effort except where technically desirable, e.g., comparison of calculated breeding ratios.

Through 1980 over $200 million has been spent on GCFR-specific work as follows:

| | |
|---|---|
| Industry | $25 million |
| DOE | $96 million |
| International | $101 million |

All the design and development work which has been done to date, both in this country and in Europe, has given positive results and the prognosis for ultimately achieving the potential advantages of the GCFR is excellent.

At the end of FY1980 the program status was as follows:

(1) The Conceptual Design of the Nuclear Steam Supply System for a 350 MW(e) Demonstration Plant had been completed.

(2) Development plans had been completed for all major components and systems.

Safety and licensing have been key considerations throughout the life of the program. In fact, a large fraction of the utility funds has been devoted to this subject. In 1971, a Preliminary Safety Information Document (PSID) on the GCFR was submitted to the AEC's Directorate of Licensing. After extensive dialogue and meetings with the ACRS, a Safety Evaluation Report was issued in 1974 by the DOL and a letter written by the ACRS also in 1974 on their respective reviews.

Recently two amendments to the PSID have been prepared for submittal to and review by the Nuclear Regulatory Commission. They relate to important safety issues raised in the reviews.

Although the Administration terminated the GCFR Program in FY1981, residual funding has allowed some work to continue at several U.S. national laboratories, particularly ORNL. Also an in-pile loop continues to operate in the BR-2 at Mol, Belgium under German auspices and heat transfer experimental and analytical work is going on both in Germany and Switzerland.

All of this work will come to an end in 1981 unless funds for the GCFR are provided in FY1982. The feeling of the utility supporters of the program was well expressed at a Program Technical Review Meeting held in mid 1980. After hearing reports on the design and development work which was going on in Europe and the United States, one of the utility representatives said from the floor "You mean all of this wonderful work which is going on will cease?". This statement is echoed in the GAO report cited. "The utility companies and industrial and engineering firms involved also told us that their efforts would probably cease if DOE terminated its program. Officials of the Helium Breeder Association told us that without DOE funding, it would not be possible for them to carry out a viable program or maintain their organization's membership. And, officials of the leading industrial proponent of GCFR, the General Atomic Company, told us that if the DOE program is terminated, it is doubtful that they would continue to spend company funds to further the program."

If funding of $10 million were to be authorized and appropriated for FY1982, which would be less than 2% of the LMFBR budget, the program would have the objective of:

(1) Continuing to advance GCFR technology and maintaining and expanding the previously developed data base.

(2) Reinitiating dialogue with the NRC on the safety and licensability of GCFR.

(3) Maintaining a viable core group of technologists at key industrial contractors and national laboratories.

(4) Resolving key heat transfer issues.

Although these objectives are limited, they would maintain the program as a viable option and focus work in areas of greatest technical uncertainty. This work would all be a part of the National Breeder Base Program.

We agree with the above-cited GAO report in their recommendation to the Congress:

"Further, a commitment to a long-term nuclear option should include continued support for the gas-cooled fast breeder reactor program since it is currently the only real nuclear alternative to the LMFBR technology. Accordingly, GAO recommends that Congress continue to fund the program at least until the program reaches a decision point on whether to construct and operate a demonstration facility. Such an approach is essential as a prudent management step in helping assure the timely success of this Nation's nuclear energy future."

Thank you for the opportunity to present this testimony.

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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TUESDAY, MARCH 3, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research, and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 2 p.m., in room 2318, the Rayburn House Office Building, Hon. Robert Young (acting chairman of the subcommittee) presiding.

Mr. Young. I would like to call the Subcommittee on Energy Research and Production into session.

Good afternoon.

I would like to ask the panel if they wouldn't mind coming up, to sit together and we all go through each one of your testimonies and then have a panel discussion.

Would you all mind coming up to the main table.

I am Congressman Bob Young of Missouri and will be chairing the hearing at the request of Mrs. Bouquard.

The purpose of the hearing is to hear testimony from non-Government witnesses on the topic of the magnetic fusion energy program.

As many of you know, the magnetic fusion program has enjoyed a reasonable amount of popularity with this subcommittee and its predecessor over the last few years. In the second session of the 96th Congress, an important first step in advancing the fusion program took place. The Magnetic Fusion Energy Engineering Act of 1980 was initiated, gained overwhelming support, passed Congress and was signed into law.

This subcommittee, and I personally, had hoped the new administration would have seen fit to try and follow this bill's aggressive yet realistic milestones.

The Department of Energy appears, however, to be sending us mixed signals in this regard. Mr. Edwards seems to say move ahead, but his acting subcabinet people keep saying no. Interestingly enough, the President's own Office of Management and Budget wants more money in the fiscal year 1982 fusion budget than the Department of Energy is requesting. This is a dilemma that the Congress will have to sort out.

I hope that our witnesses today will help us solve the fusion puzzle by giving us a better understanding of the technical readiness of the fusion program to move ahead. Congress must be on firm ground if we are to try to move forward aggressively in the framework of fiscal constraint.

Finally, we need to more fully understand the industry, utility, and university roles in the fusion energy development program, and why it is so important to push forward now with the engineering phase.

We are going to try to keep our questions as brief as we can this afternoon. Before we begin Dr. Dean's testimony I call upon Mr. Lujan, the ranking Republican member of our subcommittee, to make any opening remarks he may wish to make at this time.

Mr. LUJAN. Thank you very much, Mr. Chairman.

I would be interested in hearing what comes out of this hearing, because we are kind of flying blind as to what the budget will be.

Contrary to what I normally think, we need to put additional funds into fusion, but I rather doubt that is going to be the final product that we see coming from the Government this year.

Some of the questions that I would like to have the panel address is, how much money it would take to deliver a powerplant by 1999, which is very optimistic, I think, and dependent on whether we escalate the amount involved. That is one of the discussions I would like to hear about: How much money is needed to keep it on the present course and whether the present course is in fact the course we ought to be on?

Are there better ways to do it, maybe less expensive, or are we overlooking and not funding something that may have good promise?

Those are the kinds of things I would like to see come out of this afternoon's hearing.

If you gentlemen could approach it in that manner during your testimony, answer those questions that I have asked in the question-and-answer period after your testimony, it would be very helpful.

Thank you, Mr. Young.

Mr. YOUNG. Good morning, Dr. Dean. It is a pleasure to have you before the subcommittee again. We, in Congress, believe your association provides a valuable service in the industrial and utility community and we welcome you here this afternoon.

Dr. DEAN. Thank you very much, Mr. Chairman.

In response, Mr. Lujan, I would like to say that I do not expect fusion to receive from the new Administration the budget that President Carter submitted. We realize that these are difficult times. As the budget is shaping up in the Department of Energy, the real problem is not a problem over the exact dollar level. The real problem is whether or not the new Administration is going to enact, in policy, the spirit of the Fusion Act which the Government passed last year. We don't expect that necessarily the most aggressive implementation of the act is possible in these difficult budget times. But the basic premises of the act are correct and the basic goals are correct and what we would like to see is that the administration take a positive stand that they are going to attempt to implement the Fusion Act and to move the program as rapidly as budget circumstances will permit. That is where we have a difference of opinion with the Department of Energy right now. It is not the dollars, so much as the fact that it appears they would like to put fusion on the back burner for 4 years and then go on with it later.

This committee, through its advisory committees and through the Fusion Act, established the proper and appropriate course. It will continue to be the Congress' job to provide the money.

Mr. **Young**. Without objection we will accept your written testimony. For the record, you may proceed as you wish.

Dr. **Dean**. Thank you.

## STATEMENT OF DR. STEPHEN O. DEAN, PRESIDENT, FUSION POWER ASSOCIATES

It is a pleasure to have the opportunity to address your subcommittee at this critical time in the development of our Nation's energy policy. I say critical time because, from testimony presented by the Department of Energy last week, it seems clear that the Department is considering radical changes in energy programs which the Congress has carefully laid in place during the past few years.

It remains essential for this committee to give the executive branch considerable guidance to assure that the country has a balanced energy research and development program. The Government should exercise its responsibility to develop the technology base for a wide range of energy options while permitting market forces to determine their ultimate application and rate of entry into the marketplace.

I am especially interested in the conflicting attitudes which I hear being expressed regarding fusion energy development. Last Wednesday, in testimony to this subcommittee, the Acting Director of Energy Research stated that "the administration's commitment to making nuclear fission a fully viable source for the Nation's electric energy supply makes an acceleration of fusion development less urgent."

In response to questions, this representative indicated that the DOE has made a policy decision not to carry out many of the mandates of Public Law 96-386—the Magnetic Fusion Energy Engineering Act of 1980—which was initiated by this committee and which passed both Houses of the Congress by an overwhelming vote only a few months ago.

On the other hand, last Thursday, Secretary Edwards was quoted by news sources as saying:

> We should push fusion as fast as we can. If we can do it in 30 years, why can't we do it in 20 years. I'm an impatient man. We went to the moon in only 10 years. We want to maintain our international leadership in fusion and not lose it the way we did in nuclear.

We subscribe to that version of the Department's view and we hope the Secretary can transmit that to those on his staff that are speaking of developing policy.

Despite the Secretary of Energy's statements, some Energy Department staff policymakers are trying to create an artificial conflict between the nuclear fission breeder reactor and fusion energy programs.

In its new enthusiasm to develop the breeder reactor, the Department of Energy policy staff is trying to slow down the fusion program.

Last year, this subcommittee established a fusion advisory committee under the chairmanship of Dr. Robert L. Hirsch of Exxon to assist in the development of fusion energy policy. The DOE then established its own review panel under Dr. Solomon Buchsbaum of Bell Labs, who was chairman of their Energy Research Advisory Board. The process ultimately resulted in both the Congress and the administration endorsing the Magnetic Fusion Energy Engineering Act of 1980.

This national commitment was carefully worked out among the leaders of the fusion scientific and technical community, the executive branch, and the Congress. The act instructs the Secretary of Energy to:

> Initiate at the earliest practical time each activity which he deems necessary to achieve the national goal for operation of a commercial fusion demonstration plant at the turn of the century.

The Congress did not pass the Magnetic Fusion Act as a substitute for pursuing the fission breeder reactor. Nor does the nuclear industry consider such a choice between fusion and the breeder to be necessary or desirable.

This subcommittee should be on guard against those who would create conflict between the development of fusion technology and that of the fission breeder. An appropriate energy policy would seek to establish the necessary technological base for both fusion and the breeder, and for other energy options, and then let the marketplace determine their commercial viability.

If the DOE staff ignores the mandates of the Magnetic Fusion Energy Engineering Act of 1980, we will lose momentum and fall behind in the international race to develop this important new technology.

The United States already has lost ground to other countries in breeder reactor development. We must not allow the same situation to develop in fusion.

We must consider the advantages of maintaining and even increasing our technological edge in the international marketplace. The President has said that he wants to restore America's position of leadership in the world. With many of our older industries declining, an important key to world economic leadership will be the development of advanced technologies like fusion to fuel new industries and to meet the needs of mankind.

A fusion energy system has many potential applications and unique features which will benefit society. In an article entitled "The Coming Changes in the Chemical Industry," Mr. Earl N. Barnes, executive vice president of Dow Chemical Co., writes: "The ultimate step in the industry's metamorphosis will occur when fusion energy becomes available." He tells of how fusion energy will be used to disassociate water to hydrogen and oxygen, and how this hydrogen can be used to make any chemical desired, as well as to provide a portable fuel for hydrogen-powered vehicles.

If a strong light water reactor industry is reestablished in this country, a fusion reactor can be used to breed fuel for these reactors. Profs. Hans Bethe and Edward Teller have described calculations showing that a single fusion reactor could breed sufficient fissile fuel to continuously fuel 5 to 20 light water reactors.

Fusion reactors can, of course, also be used directly to produce electricity. In this application, the fuel for such reactors is readily available to all nations of the world and the radioactive inventory is such as to greatly reduce the human hazard from any potential accident, compared to a similar accident, however unlikely, from fission reactors. Electricity, if abundantly available, can be used to power vehicles, to heat homes, and to run factories in addition to its more conventional applications for lighting and appliances.

A primary justification for the Government to pursue the commitment established in the Fusion Act is to maintain technical leadership in an intense world fusion effort. At the present time, the U.S. program represents only about one-third of the world effort and Europe and Japan have under construction fusion devices which are larger than TFTR, the largest U.S. device now under construction.

Furthermore, the technological skills and accomplishments which result from pressing forward on the frontiers of science and technology have spinoff benefits in a wide range of near-term applications. These spinoffs play a major role in the continued evolution of an advanced technological society and depend on a dedicated cadre of scientists, engineers and organizations.

The fusion program cannot be "put on the shelf" for a few years, and simply picked up again later. Opportunities once lost may not be regained. Morale and momentum once destroyed are difficult to recapture.

The scientific and engineering communities from both the public and private sectors certified to the Government last year that the fusion program is ready to move into engineering development and that the goals of the Fusion Act are achievable and in the best interests of the country.

As president of Fusion Power Associates, I represent a group of high technology companies that are primed, ready, and anxious to jointly undertake this challenge with the Government laboratories, and universities. The American people, acting through their elected representatives, have legislated this commitment.

The new administration has urged the country to return to traditional American values. One such value is to unleash our scientific and technical creativity. This is not the time to rethink again our fusion commitment. It is time to capitalize on our scientific successes. I urge the Congress to press the implementation of the Magnetic Fusion Energy Engineering Act of 1980 as the basis for its fusion policy.

Thank you.

[The prepared statement of Dr. Dean follows:]

**FUSION POWER ASSOCIATES**

2 PROFESSIONAL DRIVE, SUITE 248 • GAITHERSBURG, MARYLAND 20760
(301) 258-0545

STATEMENT OF
DR. STEPHEN O. DEAN
PRESIDENT
FUSION POWER ASSOCIATES
TO THE
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
OF THE
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
MARCH 3, 1981

It is a pleasure to have the opportunity to address your subcommittee at this critical time in the development of our nation's energy policy. I say "critical time" because, from testimony presented by the Department of Energy last week, it seems clear that the Department is considering radical changes in energy programs which the Congress has carefully laid in place during the past few years. It remains essential for this committee to give the Executive Branch considerable guidance to assure that the country has a balanced energy research and development program. The government should exercise its responsibility to develop the technology base for a wide range of energy options while permitting market forces to determine their ultimate application and rate of entry into the marketplace.

I am especially interested in the conflicting attitudes which I hear being expressed regarding fusion energy development. Last Wednesday, in testimony to this subcommittee, the Acting Director of Energy Research stated that "the Administration's commitment to making nuclear fission a fully viable source for the nation's electric energy supply makes an acceleration of fusion development less urgent". In response to questions, this representative indicated that the DOE has made a policy decision not to carry out many of the mandates of Public Law 96-386--The Magnetic Fusion Energy Engineering Act of 1980, which was initiated by this Committee and which passed both houses of the Congress by an overwhelming vote only a few months ago.

On the other hand, last Thursday, Secretary Edwards held a press conference. News sources quoted Edwards as saying "We should push fusion as fast as we can. If we can do it in 30 years, why can't we do it in 20 years. I'm an impatient man. We went to the moon in only 10 years. We want to maintain our international leadership in fusion and not lose it the way we did in nuclear". I agree with the Secretary rather than with his representative.

"TO TAKE FROM THE SEA AND TO IMITATE THE SUN"

Last year, this Subcommittee established a Fusion Advisory Committee under the Chairmanship of Dr. Robert L. Hirsch of Exxon to assist in the development of an imaginative fusion energy policy. The DOE then established its own review under Dr. Solomon Buchsbaum of Bell Labs, who is Chairman of their Energy Research Advisory Board. The process ultimately resulted in both the Congress and the Administration endorsing the Magnetic Fusion Energy Engineering Act of 1980 just a few months ago. This national commitment was carefully worked out among the leaders of the fusion scientific and technical community, the Executive Branch, and the Congress. The Magnetic Fusion Energy Engineering Act of 1980 instructs the Secretary of Energy to "initiate at the earliest practical time each activity which he deems necessary to achieve the national goal for operation of a commercial fusion demonstration plant at the turn of the century". The Congress did not pass the Magnetic Fusion Act as a substitute for pursuing the fission breeder reactor. Nor do I believe that the nuclear industry considers such a choice between fusion and the breeder to be necessary or desirable. This Subcommittee should be on guard against those who would create an artificial conflict between the development of fusion technology and that of the fission breeder. An appropriate energy policy would seek to establish the necessary technological base for both fusion and the breeder, and for other energy options, and then let the marketplace determine their commercial viability.

A fusion energy system has many potential applications and unique features which will benefit society. In an article entitled "The Coming Changes in the Chemical Industry" Mr. Earl B. Barnes, Executive Vice President of Dow Chemical Company, writes "The ultimate step in the industry's metamorphosis will occur when fusion energy becomes available". He tells of how fusion energy will be used to disassociate water to hydrogen and oxygen and how this hydrogen can be used to make any chemical desired, as well as to provide a portable fuel for hydrogen powered vehicles.

If a strong light water reactor industry is reestablished in this country, a fusion reactor can be used to breed fuel for these reactors. Professor Hans Bethe and Professor Edward Teller have described calculations showing that a single fusion reactor can breed sufficient fissile fuel to continuously fuel five to twenty light water reactors.

Fusion reactors can, of course, also be used directly to produce electricity. In this application, the fuel for such reactors is readily available to all nations of the world and the radioactive inventory is such as to reduce, by orders of magnitude, the human hazard from any potential accident, compared to a similar accident, however unlikely, from a nuclear fission reactor. Electricity, if abundantly available, can be used to power vehicles and to heat homes, in addition to its more conventional applications for lighting and appliances.

A primary justification for the Government to pursue the commitment established in the Fusion Act is to maintain technical leadership in an intense world fusion effort. At the present time, the U.S. program represents only about one-third of the world effort and fusion devices are under construction in Europe and Japan which are larger than TFTR, which is the largest U.S. device now under construction. Furthermore, the technological skills and accomplishments which result from pressing forward on the frontiers of science and technology have spinoff benefits in a wide range of near-term applications. These spinoffs play a major role in the continued evolution of an advanced technological society and depend on a dedicated cadre of scientists, engineers and organizations. This program cannot be "put on the shelf" for a few years, and simply picked up again later. Opportunities once lost may not be regained. Morale and momentum once destroyed are difficult to resurrect. The scientific and engineering communities from both the public and private sector have certified to the government that the fusion program is ready to move into engineering development and that the goals of the Fusion Act are achievable and in the best interests of the country.

As President of Fusion Power Associates, I represent a collection of high technology companies that are primed, ready and anxious to jointly undertake this challenge with the government laboratories, and universities. The American people, acting through their elected representatives, have legislated this commitment. The new administration has urged the country to return to traditional American values. One such value is to unleash our scientific and technical creativity. This is not the time to rethink again our fusion commitment. It is time to capitalize on our scientific successes. I urge the Congress to press the implementation of the Magnetic Fusion Energy Engineering Act of 1980 as the basis for its fusion policy.

**FUSION POWER ASSOCIATES**
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(301) 258-0545

Fusion Power Associates is a non-profit, tax-exempt corporation established to ensure the timely development and acceptance of fusion as a socially, environmentally and economically attractive source of energy. To fulfill this purpose, we have adopted three primary goals:

- To ensure a smooth, timely transition from scientific research on fusion to engineering development and practical application.
- To foster cooperation in fusion research and development among all public and private organizations including government, universities, national laboratories and industry.
- To establish increased public awareness and understanding of the potential of fusion energy.

Members:

Aydin Energy Division (Palo Alto, CA)
BDM Corporation (McLean, VA)
Boeing Engineering and Construction Co. (Seattle, WA)
Burns and Roe, Inc. (Oradell, NJ)
Ebasco Services (New York, NY)
EDS Nuclear, Inc. (San Francisco, CA)
General Atomic Company (San Diego, CA)
Gilbert/Commonwealth Engineers and Consultants (Reading, PA)
Hipotronics (Brewster, NY)
ILC Technology (Sunnyvale, CA)
JAYCOR (Del Mar, CA)
KMS Fusion, Inc. (Ann Arbor, MI)
Mathematical Sciences Northwest (Bellevue, WA)
Maxwell Laboratories (San Diego, CA)
McDonnell Douglas Astronautics Co. (St. Louis, MO)
PSE&G Research Corp. (Newark, NJ)
Quadrex Corporation (Campbell, CA)
W. J. Schafer Associates (Arlington, VA)
Science Applications, Inc. (San Diego, CA)
Stone and Webster Engineering Corp. (Boston, MA)
Metals Division, Thermo-Electron Corp. (Woburn, MA)
TRW (Redondo Beach, CA)
Universal Voltronics (Mt. Kisco, NY)
Westinghouse Electric Corp. (Pittsburgh, PA)

Affiliates:

Bendix Corporation (Southfield, MI)
Dow Chemical Corp. (Midland, MI)
Institut de Recherche de l'Hydro Quebec (Quebec, Canada)
Long Island Lighting Co. (Hicksville, NY)
Northeast Utilities (Hartford, CT)
Northern States Power Co. (Minneapolis, MN)
Pennsylvania Power and Light Co. (Allentown, PA)
Ralph M. Parsons Co. (Pasadena, CA)
Texas Atomic Energy Research Foundation (Dallas, TX)
Tri-City Nuclear Industrial Council (Pasco, WA)
Phillips Petroleum Company (Bartlesville, OK)

"TO TAKE FROM THE SEA AND TO IMITATE THE SUN"

Mr. YOUNG. Thank you, Doctor.

Mr. Blattner, without objection we will accept your testimony for the record and that of all of the other panel members and then we will ask you all to proceed in any way you would like to proceed on your own.

Mr. Blattner.

## STATEMENT OF CALVIN J. BLATTNER, VICE PRESIDENT, ENGINEERING, McDONNELL DOUGLAS ASTRONAUTICS CO.

Mr. BLATTNER. Mr. Chairman, members of the subcommittee, may I begin by presenting my associates. On my right is Dr. Don Kummer, director of fusion energy programs and on my left is Mr. Bill Briggs, director of fusion energy program development. With your permission, I will read some highlights of the written testimony, which has been given to you, and then support the panel in answering any questions you may have.

McDonnell Douglas received its first fusion contract in 1974. We have worked on a wide variety of tasks including design studies and the fabrication of fusion hardware. We have recently completed two design studies of complete fusion powerplants which might be expected to operate early in the next century. These were under the leadership of two national laboratories. The study which was based on the Tokamak concept has been named Starfire. A film has been made to summarize the study in about 10 minutes. With your permission, I will show it now.

A similar, but less comprehensive study of a plant based on the Elmo Bumpy Torus concept has also been completed under the direction of the Los Alamos Scientific Laboratory. There are three illustrations here: The Elmo Bumpy Torus reactor, the Starfire Tokamak reactor and an entire powerplant pictured with a Tokamak reactor. Both the Starfire and Elmo Bumpy Torus studies showed that fusion power will be economically competitive with other types of powerplants and that fusion plants will have a high degree of safety with minimal impact on the environment.

I will now address the Elmo Bumpy Torus proof of principle project for which we are prime contractor under the Union Carbide Corp./Nuclear Division at the Oak Ridge National Laboratory.

I have two illustrations: One is the experimental device and the other is the facility we will build in the Oak Ridge Valley Industrial Park on land we have purchased.

In the magnetic fusion program, the Elmo Bumpy Torus is the leading alternate fusion concept relative to the Tokamak and mirror. One reason for this is its potentially attractive features as a commercial power reactor. It operates continuously rather than in a pulsed mode. It will not need an energy storage system, as would be needed in a pulsed system, and will have a longer reactor lifetime because of the absence of frequent on-off cycles.

Because of its high aspect ratio shape, like a bicycle tire, it is comparatively easy to build and maintain. These features all promise economic advantages. The proof-of-principle project objective is to test the physics at a level which allows a determination of the concept's potential as a commercial reactor. A comparison with the Tokamak and mirror concepts can then be made to determine the best way to develop fusion's highest potential.

This project is the proper step at the proper time. It has been studied by many groups over the past 3 years. The results have all been positive.

The reasons for pursuing the EBT-P project are the same now as they were in 1978 when it was selected as the leading alternate fusion concept. Its technology and physics base is as solid today as it was in 1978 and there have been no new problems discovered.

A unique feature of the Elmo Bumpy Torus proof-of-principle project is the past and future commitment of industry. It is one of only a few long-term, high-technology energy projects where industry has invested as much or more money than DOE.

Regarding the Fusion Engineering Device and Center for Fusion Engineering, the directive in the Magnetic Fusion Act of 1980 to proceed into the engineering phase is well considered and timely. The Fusion Engineering Device will provide basic engineering data that is applicable to all fusion concepts and will demonstrate the engineering feasibility of fusion. It is recommended that a dynamic program be instituted.

In conclusion, the time required to design and build fusion experiments is long and the results are not totally predictable. The Office of Fusion Energy has based their decisions on the best possible technical information within the limits of such considerations as budget and schedule.

It is important that a technically oriented management emphasis be continued and supported to insure that a consistent and effective program is maintained. We recommend, with other members of industry, that this well-managed program be supported and further implemented at an aggressive pace.

Thank you for the opportunity to present our views to the committee.

[The prepared statement of Mr. Blattner follows:]

# STATEMENT OF

# CALVIN J. BLATTNER

VICE PRESIDENT - ENGINEERING

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY - ST. LOUIS, MO.

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION

MARCH 3, 1981

Magnetic Fusion Energy; an Industrial Viewpoint - Mr. Chairman, Members of the Subcommittee, it is a privilege to present our thoughts on the Magnetic Fusion Energy program to the Subcommittee. Fusion is a program in which the role of industrial organizations has grown rapidly in the past few years. Our presence here today is evidence of the fact that major responsibilities have been tranferred from the fusion Laboratories to industry and of our belief in the ultimate utility of this unlimited form of energy.

EXPERIENCE - McDonnell Douglas received its first fusion contract in 1974. It was a good time to complement the large gains being made in physics with engineering from a high technology company. Some initial system analyses and design studies were made to identify the most promising directions for research and development. Early system studies of the components of a fusion reactor which contain the burning plasma produced some valuable conclusions, some of which countered accepted assumptions. One example is that very high magnetic fields and high neutron wall loadings do not result in cheaper electricity production even though they result in a smaller reactor. Identifying these types of factors helps focus technology development into the most productive channels.

These early system studies led to design studies of future fusion power plants. Two such studies have recently been completed. Under the leadership of Argonne National Laboratory, a team headed by McDonnell Douglas made a $2 million design study of a commercial tokamak power plant expected to operate early in the next century. This STARFIRE study involved experienced engineers and scientists from electric utilities, an engineering construction company (The Ralph M. Parsons Company), an energy company (General Atomic), universities and national laboratories. A similar but less comprehensive study of a power plant based on the Elmo Bumpy Torus concept has also just been completed under the direction of the Los Alamos Scientific Laboratory. Both studies showed that fusion power will be economically competitive with other types of power plants and that fusion plants will have a high degree of safety with minimal impact on the environment.

Fusion hardware is being built today in our St. Louis plant. We are producing ion sources for the Princeton Plasma Physics Laboratory's Tokamak Fusion Test Reactor (TFTR) and General Atomic's Doublet III. These units require precision fabrication and utilize advanced materials. They were developed at the Lawrence Berkeley National Laboratory and the necessary information for manufacturing them has been transferred to industry. We have also designed and built antenna systems for Ion Cyclotron Resonance Heating experiments on the Elmo Bumpy Torus-Scale (EBT-S) device at the Oak Ridge National Laboratory.

In addition to fusion studies and hardware we are the industrial contractor for the Elmo Bumpy Torus Proof of Principle experiment. The Oak Ridge National Laboratory has developed this fusion concept and is directing the project. It will be the first time industry will be responsible for the design, fabrication, installation, and checkout of a complete fusion device.

BROAD BENEFITS FROM THE HIGH TECHNOLOGY FUSION PROGRAM - Being a company that participates fully in the United States space program, we see a number of parallels between accomplishing space goals and accomplishing fusion power goals. The House Science and Astronautics Committee, which was born with the space age, helped focus the national resolve to put men on the moon. It was done in far less time than was imagined to be possible before the Science and Astronautics Committee was formed. The enormous technical advances that came from the space program spawned new technology and industries that gave a surge to our Nation's capabilities and helped the U.S. remain in the forefront of technology for two decades.

There are distinct parallels to achieving fusion power. It is a significant technical challenge that will require advancing the knowledge of physics and engineering. Meeting this challenge will yield enormous benefits in new capabilities and stature for our nation. Again the control lies with the Science and Technology Committee where this potential is understood. This Committee again has the opportunity to provide leadership in making a long term commitment to the goal of fusion power. Another benefit from an aggressive fusion program is the export potential of this high technology product. Other countries whose export plan is based on high technology products are diligently at work and we must not let them overtake us.

The Magnetic Fusion Energy program has been well managed. A wide community of participants has been used to advantage. Reviews by selected experts have been made periodically to evaluate the program and identify the most advantageous directions. The Ad Hoc Experts Group on Fusion recommended in 1978 a strategy to pursue fusion on a broad front. "We emphasize again the necessity to pursue in parallel with scientific experiments, engineering feasibility studies of the most promising alternatives." This gave emphasis to the alternate concepts work that will be briefly described later.

The Subcommittee on Energy Research and Production formed a Fusion Advisory Panel in 1979. Its recommendation was, "based on significant technical progress, the magnetic fusion program is now ready to move aggressively into an engineering phase aimed at commercialization by the year 2000."

An Energy Research Advisory Board, established by the Director of Energy Research of the Department of Energy, reviewed the magnetic fusion program in

1980. It determined that a dynamic program is warranted to move into the engineering development stage.

All of these reviews have been positive. The Magnetic Fusion Act of 1980 sponsored by the House Science and Technology Committee authorized an aggressive fusion engineering program.

THE ELMO BUMPY TORUS PROOF OF PRINCIPLE PROJECT - In the Magnetic Fusion program, the Elmo Bumpy Torus or EBT is the leading alternate fusion concept relative to the tokamak and mirror. One reason for this is its potentially attractive features as a commercial power reactor. It operates continuously rather than in a pulsed mode. It will not need an energy storage system, as would be needed in a pulsed system, and will have a longer reactor lifetime because of the absence of frequent on-off cycles. Because of its high aspect ratio shape, like a bicycle tire, it is comparatively easy to build and maintain. These features all promise economic advantages.

The Elmo Bumpy Torus Proof of Principle (EBT-P) project objective is to test the physics at a level which allows a determination of the concepts potential as a commercial reactor. A comparison with the tokamak and mirror concepts can then be made to determine the best way to develop fusion's highest potential.

The EBT-P project will develop technology which is useful to all of the fusion program. During its initial operation in 1985, it will demonstrate the operation of many (36) superconducting magnets arranged in a torus. It will also advance the technology and contribute to our understanding of the physics of heating the plasma with radio frequency energy.

This project is the proper step at the proper time. It has been studied and reviewed by many groups over the past three years. The results have all been positive. In 1978, the Ad Hoc Experts Group on Fusion recommended pursuing attractive alternate concepts. The DOE alternate concept review held in 1978 selected the EBT for advancement to the proof of principle level. Five independent EBT-P Project Definition Studies were conducted in 1979 by the Oak Ridge National Laboratory and four industrial teams. The EBT-P reference design was produced from these five studies. A DOE peer panel reviewed the reference design, found that it was adequate and recommended expansion of the physics goals. The Energy Research Advisory Board review in 1980 encouraged expanded work on EBT. It also asked for a review of the physics base before starting construction of EBT-P and an examination of any lower cost options. This last request has been investigated under the leadership of the Oak Ridge National Laboratory and the reference design was found to be the most cost effective approach.

A unique feature of the EBT-P project is the past and future commitment by industry. This is one of few long term, high risk technology energy projects where industry has invested as much or more money than DOE. Since the start of EBT work at McDonnell Douglas in 1977, we have spent in excess of $3 million of company funds. We estimate that the three other large industry teams combined spent $3 million in the project definition studies completed in 1979. In the future, McDonnell Douglas will invest $10M of its funds to build a facility at Oak Ridge to house the EBT-P device. We have already purchased the property and awarded a contract to an architectural and engineering firm for preliminary design of the buildings.

Industry has a valuable contribution to make to the fusion program. The motivation for industry to make a commitment must be secured by consistent Government funding policies and practices. The reasons for pursuing the EBT-P project are the same now as they were in 1978 when it was selected as the leading alternate fusion concept. Its technology and physics base is as solid today as it was in 1978 and there have been no new problems discovered.

FUSION ENGINEERING DEVICE AND THE CENTER FOR FUSION ENGINEERING - The directive in the Magnetic Fusion Act of 1980 to proceed into the engineering phase is well considered and timely. The centerpiece of continuing fusion development is the Fusion Engineering Device (FED) using the tokamak concept. It will focus the development of technology and reactor components. The Fusion Engineering Device will provide basic engineering data that is applicable to all fusion concepts and demonstrate the engineering feasibility of fusion. It is recommended that a dynamic program be instituted. The promise of fusion power and the new technology that will flow from fusion R&D warrant a vigorous plan. It should move at an optimum pace and with consistent funding. Establishing a new Center for Fusion Engineering will centralize engineering and complement the existing fusion physics laboratories. This organizational activity should be accomplished rapidly to conserve the technical continuity now in the program. Addressing engineering feasibility questions early through the Center for Fusion Engineering will produce, we believe, an effective plan for introduction of fusion into the commercial market.

FUSION MATERIALS TESTING - Basic to engineering design is a thorough knowledge of the materials. Much fundamental work must be done with materials that might be used to surround the reacting plasma. We can do all of the materials tests except those that evaluate the effect on materials of high energy neutrons (which transfer energy from the plasma to the thermal power system). The extent to which they alter the properties of materials must be thoroughly understood to enable the design and construction of long life and reliable reactor first wall and blanket components. A facility is needed that provides a large quantity of 14 million electron volt neutrons in a test volume suitable for materials property determination.

FUSION POWER WILL BE COST COMPETITIVE, SAFE AND CLEAN - To make as valid a comparison of cost as possible, we assembled some recent studies and actual performance data of fission and coal fueled power plants made by utility and construction companies. This comparison is shown in the attached figure. Assuming that the STARFIRE fusion power plant could be completed in 1986, its cost of electricity would be competitive with fission and coal plants. Much of the annual increase in the cost of electricity produced by fossil and fissile fuels is due to rising fuel prices. Since the cost of deuterium, which will be the only procured fuel of a fusion power plant, is negligible, fusion cost escalation will be much less than that of fossil and uranium fueled power plants.

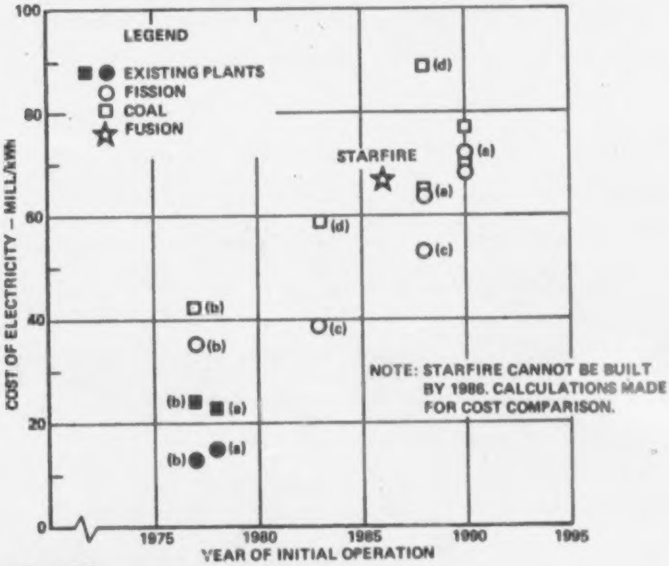
Fundamentally, fusion power is safe because the very hot plasma self-quenches in response to any anomaly in plant operation. Through the proper choices of materials such as water coolant and a solid compound of lithium for tritium breeding, there are no large reservoirs of chemical potential energy. Fusion does not yield products of combustion such as carbon dioxide or nitrogen oxides. The radioactive tritium fuel is made and consumed in the reactor and the quantity subject to release by an accident can be minimized by design.

Structural materials exposed to the plasma will become activated, however, the activated material is tied up in a solid and durable metal where it is easy to store and retain until it decays.

The time required to design and build fusion experiments is long and the results are not totally predictable. The Office of Fusion Energy has based their decisions on the best possible technical information within the limits of such considerations as budget and schedule. It is important that a technically oriented management emphasis be continued and supported to ensure that a consistent and effective program is maintained.

Fusion energy promises to provide a new source of power for the nation and the world. Additionally, it will generate new technology that will help maintain technical leadership throughout the world. McDonnell Douglas is solidly in the fusion program and investing in its future. We recommend, with other members of industry, that this well managed program be supported and further implemented at an aggressive pace.

Thank you for the opportunity to present our views to the Committee.



FUSION POWER: COST COMPETITIVE

NOTE: STARFIRE CANNOT BE BUILT BY 1986. CALCULATIONS MADE FOR COST COMPARISON.

DATA SOURCES
(a) REFERENCE 13, EBASCO SERVICES INC.
(b) REFERENCE 14, COMMONWEALTH EDISON COMPANY
(c) REFERENCE 12, UNION ELECTRIC COMPANY – PRELIMINARY ESTIMATE FOR PWR UNDER CONSTRUCTION
(d) REFERENCE 12, UNION ELECTRIC COMPANY

Mr. YOUNG. Thank you very much, Mr. Blattner.

I would like to welcome our ranking minority member to the subcommittee hearing this afternoon, Mr. Winn.

Mr. WINN. Thank you.

Mr. YOUNG. Would you like to proceed, Dr. Miley; your statement will go into the record and we would like you to proceed in any manner you would like to proceed.

## STATEMENT OF DR. GEORGE MILEY, CHAIRMAN, NUCLEAR ENGINEERING PROGRAM, AND DIRECTOR, FUSION STUDIES LABORATORY, UNIVERSITY OF ILLINOIS

Dr. MILEY. I have filed a written statement so, with you permission, I will present some additional thoughts in parts of this oral presentation. The key issue I would like to address is the long leadtime that is required for manpower development and the disastrous effects that cutbacks at this time will have on that development.

Before I do that, I would like to give you some background on the University Fusion Association (UFA) which I am representing. It was founded over a year ago to help the university faculty who are active in fusion research stay abreast of fusion activities and policy decisions at the national level and to provide a communication channel with other organizations like DOE and congressional committees.

Over 150 charter members represent unversities in almost every State across the country. Also, DOE's Office of Magnetic Fusion Energy recently added a UFA representative to the Fusion Power Coordinating Committee.

I am appearing today in my capacity as secretary-treasurer of the UFA. Unfortunately, Dr. Ravi Sudan, our current chairman, is ill and is not able to be with us, as much as he would like to be. This statement was prepared in consultation with a subcommittee of UFA's executive committee, so it has, I believe, a representative point of view.

The overriding question now facing the Energy Research and Production Subcommittee is whether or not during this time of economic stress the national fusion program should be moved into the engineering phase as proposed in the Magnetic Fusion Engineering Act of 1980, Public Law 96-386, following the Buchsbaum report.

The membership feels that the answer should be "yes" and that this initiative is indeed essential.

UFA strongly endorses the thrust of this act, applauding the proposed plan to launch an aggressive engineering program in parallel with programs to:

> Initiate or accelerate existing activities in research areas; maintain an aggressive plasma confinement research program; maintain a broadly based research program on alternate confinement concepts and on advanced fuels; and, assess the adequacy of the projected supply of manpower in the required engineering and scientific disciplines.

If the Government now turns its back on this resolution as previous speakers have indicated, we feel the disruption of support will demoralize persons working on fusion R. & E. and surely delay progress beyond any time estimate based on simple estimates you could make based on progress charts or stoppages in work.

The key point is that the leadtime item in any project like this really revolves around manpower development and any changes that affect this are going to be much more time consuming in the long range than would be projected by pure budget estimates.

Fusion power development is both the most exciting and demanding scientific and engineering endeavor facing mankind today. As Dr. Pewitt of DOE stated in his testimony last week, "Fusion is one of the major options that may provide access to an inexhaustible energy resource base that could serve this Nation, and the world, for centuries to come."

We need the best scientific and engineering talent possible working on this most difficult but important challenge. This is the university mission. However, we need leadtime and the resources to do the job.

In the early years of fusion research, bright physicists were attracted by the excitement of plasma physics, and universities played a key role in bringing this field to the state of understanding that allowed the Buchsbaum committee to recommend an accelerated development pace.

This is not to say that the support of basic research program can be neglected. Much remains to be done and the area must be strengthened to exploit the present state of the art and to explore alternate approaches in our attempt to achieve fusion's highest potential.

This is a subject that deserves more discussion, but the issue at hand now is when and how to move ahead with fusion engineering and technology. I would like to address that, particularly to look more at the potential effects that the decision to be made in the coming months may have on universities in their role in this new fusion engineering field.

Indeed a relatively important and enthusiastic fusion engineering community is emerging. Thus, when DOE initiated a magnetic fusion energy technology fellowship program this winter, 10 universities were identified as participants based on their proven contributions to date.

As this statement was being composed a second meeting of the fellowship committee was in progress and it appears that an additional university will be added. While over 100 superbly qualified applicants are being reviewed for these national fellowships, only 6 will be selected.

Although the response to the fellowship program clearly demonstrates the potential for a strong university involvement in fusion engineering, much more must be done to make this the true partnership with the national laboratories and industry envisioned in the Fusion Engineering Act of 1980.

The fellowship/traineeship program should be expanded, and I think of equal, if not prime, importance, that simultaneously strong university research projects must be developed in order to attract superb staff and bright students and to provide them with the challenging activities necessary for a sound educational experience. This will require accelerated funding and a determination by DOE to use universities as a significant contributor to the basic fusion engineering R. & D. program, as they indicated they wanted to do.

Before I talk more about that I want to first note what types of research are the universities to be involved in as a part of the engineering/technology effort; in fusion.

Examples include a wide range of activities such as conceptual reactor studies, plasma engineering, materials engineering, energy conversion and storage, pulsed power technology, and superconducting magnet technology.

Some technologies are unique to fusion alone, such as radiofrequency plasma heating and neutral-beam and pellet heating/fueling. Still others have points of reference to existing technologies, that is, thermal hydraulics, magnets, environmental constraints, and power equipment, but have gone into completely new regimes, radiation environment, performance, and size, which put them in a class by themselves.

Only through an integrated research effort focused on fusion applications can these unique problems be solved. The important thing to understand is that the issues are much more basic than those faced in earlier development projects undertaken by the United States, such as the space program of the sixties.

For this reason, engineering research and development assumes a more demanding role. Fortunately, the problems involved in fusion engineering are well suited for study in universities and indeed a start in this direction has been made. If this effort is carefully nurtured, it could provide the rallying point that would attach the faculty and bright students necessary to ultimately insure success in the development of fusion power.

An important aspect of this problem, which I am sure the committee recognizes, is the growing "crisis" in education in engineering. Your "sister" subcommittee is meeting down the hall on this topic with more people in the room than you have here. I had in my written statement more comments about the "crisis" but I will summarize the fact the graduate schools in science and engineering are facing a continual decline in the number of graduate students. Further there are something like 2,000 engineering faculty positions open today—about 10 percent of the total number of positions in the United States. This is due to a complex combination of declining prestige of graduate education in the view of the public and low academic salaries compared to industry. This "crisis" will adversely affect industry and our Defense Establishment unless it is quickly solved.

Fusion engineering is coming in at a time when it is going to be right in the middle of this crisis.

If we cut back in the effort at this moment, I would see no hope for fusion engineering moving ahead in the midst of this turmoil.

No matter how you make the computation, to delay now would put the time schedule beyond that hoped for in fusion engineering in 1980, beyond the time hoped for by any individual in this room.

In conclusion, fusion has reached the threshold of a new phase of fusion engineering. The universities, along with Government laboratories and industry must share this challenge. Indeed, there is an ultimate and intimate connection between the key elements involved, research, manpower development and major project activities.

The mission-oriented projects, in addition to providing direct data, serve to stimulate and provide focus for research and educational activities. In turn, research and education are an essential base for the ultimate success of these projects.

The intimate connection is that if one piece is missing, the whole stack of cards may well collapse. In view of the leadtime involved, industry cannot play a leading role in university support, nor can industry or Government laboratories substitute in the basic research or educational roles.

Clearly, Congress, the administration, and DOE must share the responsibility of working with the universities and vice versa to insure they are in a position to meet this challenge.

UFA stands ready to work with you in this endeavor.

Thank you for inviting us to participate in this hearing.

[The prepared statement of George Miley follows:]

Statement of George H. Miley
Chairman, Nuclear Engineering Program, and
Director, Fusion Studies Laboratory
University of Illinois
103 S. Goodwin Ave.
Urbana, Illinois 61801
Representing the University Fusion Association (UFA)
Before the
Energy Research and Production Subcommittee
of the House Committee on Science and Technology

March 3, 1981

## Background on UFA

The University Fusion Association (UFA) was formed over a year ago. It serves to help University faculty who are active in fusion research stay abreast of fusion activities and policy decisions at the national level and to provide a communication channel with other organizations like DOE and congressional committees. Over 150 charter members represent universities in almost every state across the country. Also, DOE's Office of Magnetic Fusion Energy recently added a UFA representative to the Fusion Power Coordinating Committee.

I am appearing today in my capacity as Secretary-Treasurer of the UFA. Unfortunately, Dr. Ravi Sudan, our current chairman, is ill and is not able to join us. This statement was prepared in consultation with a subcommittee of UFA's executive committee, so it is thought to be representative of membership views.

## A View of the Problem

The overriding question now facing the Energy Research and Production Subcommittee is whether or not during this time of economic stress the national fusion program should be moved into the engineering phase as proposed in the Magnetic Fusion Engineering Act of 1980 (Public Law 96-386), following the Buchsbaum Report. We feel that the answer should be yes and that this initiative is indeed essential. UFA strongly endorses the thrust of this act, applauding the proposed plan to launch an aggressive engineering program in parallel with programs to "initiate or accelerate existing activities in research areas; maintain an aggressive plasma confinement research program; maintain a broadly based research program on alternate confinement concepts and on advanced fuels; and, assess the adequacy of the projected supply of manpower in the required engineering and scientific disciplines." If the government now turns its back to this resolution, the disruption of support will demoralize persons working on fusion R & D and surely delay progress beyond any time estimate based on simple changes in milestones and project charts. The key point I wish to leave with the committee today is the long time scale required to build up the scientific/engineering manpower base needed for fusion development and the devastating impact that a loss of momentum in the program would have on manpower development at this time.

## The University Mission

Fusion power development is both the most exciting and demanding scientific and engineering endeavor facing mankind today. As Dr. Pewitt of DOE stated in his testimony last week, "Fusion is one of the major options that may provide access to an inexhaustible energy resource base that could serve this nation, and the world, for centuries to come." We need the best scientific and engineering talent possible working on this most difficult but important challenge. This is the University mission. However, we need lead time and the resources to do the job. In the early years of fusion research bright physicists were attracted by the excitement of plasma physics, and universities played a key role in bringing this field to the state of understanding that allowed the Buchsbaum Committee to recommend an accelerated development pace. This is not to say that the support of basic research program can be neglected. Much remains to be done and the area must be strengthened to exploit the present state-of-the-art and to explore alternate approaches in our attempt to achieve "fusion's highest potential". This is a subject that deserves more discussion -- but the issue at hand now is when and how to move ahead with fusion engineering and technology. Little has been said about the potential effect that this decision could have on universities and their role in fusion engineering.

## The University Fusion Engineering Community

Indeed a relatively important and enthusiastic community is emerging. Thus, when DOE initiated a Magnetic Fusion Energy Technology Fellowship Program this winter, ten universities were identified as participants based on their proven contributions to date. As this statement was being composed a second meeting of the Fellowship Committee was in progress and it appears that an additional university will be added while over 100 superbly qualified applicants are being reviewed for six national Fellowships.

Although the response to the fellowship program clearly demonstrates the potential for a strong University involvement in fusion engineering, much more must be done to make this the true partnership with the national laboratories and industry envisioned in the Fusion Engineering Act of 1980. The fellowship/traineeship program should be expanded, but simultaneously strong university research projects must be developed in order to attract superb staff and bright students and to provide them with the challenging activities necessary for a sound educational experience. This will require accelerated funding and a determination by DOE to use universities as a significant contributor to basic fusion engineering R & D.

## Research in Fusion Engineering

What types of research are the universities to be involved in as a part of the engineering/technology effort? Examples include a wide range of activities such as conceptual reactor studies, plasma engineering, materials engineering, energy conversion and storage, pulsed power technology, and superconducting magnet technology. Some technologies are unique to fusion alone, such as radio-frequency plasma heating and neutral-beam and pellet heating/fueling. Still others have points of reference to existing technologies (i.e. thermal hydraulics, magnets, environmental constraints, and power equipment), but have gone into completely new regimes (radiation environment, performance, and size) which put them in a class by themselves. Only through an integrated research effort focussed on fusion applications can these unique problems be solved. The important thing to understand is that the issues are much more basic than those faced in earlier development projects undertaken by the U.S. such as the space program of the 60's. For this reason, engineering research and development assumes a more demanding role. Fortunately, the problems involved in fusion engineering are well suited for study in Universities and indeed a start in this direction has been made. If this effort is carefully nurtured, it could provide the rallying point that would attach the faculty and bright students necessary to ultimately insure success in the development of fusion power.

## Fusion and the "Crisis" in Graduate Education

As has been widely discussed over the past year, graduate education in U.S. universities is facing a "crisis" with declining enrollments, unfilled faculty positions, and slowly deteriorating equipment and facilities. Yet, the demands for scientific manpower continue to grow as we recognize the need to develop new technologies and to improve our productivity in order to maintain industrial leadership and revitalize our economy.

Indeed, at this very moment Dr. D. C. Drucker, Dean of the College of Engineering at the University of Illinois, is testifying on this subject before your "sister" subcommittee on Science Research and Technology. I quote from his prepared statement: "The increasing shortage of engineering faculty, facilities, and instructional equipment, in face of the enormous and still growing attraction of engineering to the best and greatest number of undergraduates ever in our history, brings our engineering education system closer and closer to a point of instability." He cites the current figure of 10%, or 2000, unfilled engineering faculty positions nation wide and predicts that the shortage "will become ever more acute over the next few years and will become catastrophic in less than a decade unless substantial corrective measures can be taken." Attention is called to "the inevitable and irretrievable adverse effects on our industrial and defense capability unless something substantive is done very soon." Dean Drucker proposes a seed money response from NSF, while the universities themselves, mission agencies, industries, state governments, and private donors make the major contributions.

With this rather dismal picture in mind, we must recognize the fact that fusion, as a "flagship" new technology, must face this problem squarely. With the momentum in fusion engineering just beginning to mount, a step backwards at this time would, I believe, throw us into the "instability" feared by Dean Drucker. We can not turn support on and off like a water faucet and expect the best minds to be attracted into an area. The university community is looking for a clear signal that a vigorous program in fusion technology is going to be mounted. If it isn't, and people are turned away, considerable time would be required to re-establish such a program again in the future. And time is not something we have! Establishment of the trained manpower base indeed represents the lead time element in a major scientific program like fusion. Time is required to attract the bright people to start with. Initial decisions may be made as early as high school or as a beginning undergraduate. Graudate school requires over a year for a M.S. and three to five years for a Ph.D. Then several years of experience in a particular program are usually necessary before a person really begins to contribute. If a negative signal is generated now -- if, for example, it appears that the U.S. is going to delay a serious program for five years, we lose our start. Then, when the decision is made to accelerate again, there will be a lag of years while enthusiasm is rekindled. No matter how the computation is made, a delay now would ultimately put the fusion power time scale far behind that hoped for in the Fusion Engineering Act of 1980.

## Conclusion

Fusion has reached the threshold of a new phase of fusion engineering. The Universities, along with government laboratories and industry, must share this challenge. Indeed, there is an intimate connection between the key elements involved -- research, manpower development, and major project activities. The mission orientated projects, in addition to providing direct data, serve to stimulate and provide focus for the research and educational activities. In turn, research and education are an essential base for the ultimate success of the projects.

In view of the lead time and money involved, industry can not play a major role in university support, nor can industry (or the government laboratories) substitute in the basic research or educational roles. Clearly, then, Congress, the Administration, and DOE must share the responsibility of working with the Universities to ensure that they are in a position to meet this challenge. UFA stands ready to work with you in this endeavor.

George H. Miley

George H. Miley is Professor of Nuclear and Electrical Engineering, Chairman of the Nuclear Engineering Program, and Director of the Fusion Studies Laboratory at the University of Illinois in Urbana-Champaign. After receiving his PhD in 1959 from the University of Michigan, he worked several years in the Nuclear submarine program at the Knolls Atomic Power Laboratory before going to Illinois.

While his research interests have ranged from nuclear reactor kinetics to nuclear pumped lasers, he is best known in the fusion community, having authored two books, Direct Energy Conversion and Fusion Energy Conversion, along with many technical publications related to both magnetic and inertial confinements and also to advanced fuel fusion. He has directed the IEEE Minicourses on Fusion, the ANL-AUA Faculty Institutes on Fusion, and is a consultant in fusion for several national laboratories and industrial groups.

He received the 1977 Western Electric Fund Award in recognition of research and teaching accomplishments; prior to that a 1975-76 Senior NATO Fellowship in fusion and the 1973 ASEE award for outstanding young Nuclear Engineering Educator. He is a fellow and on the board of directors of the American Nuclear Society, a founding member of the Society for Advancement of Fusion Energy Association (SAFE), Secretary-Treasurer of the University Fusion Association (UFA), editor of the new ANS journal, Nuclear Technology/Fusion, and general chairman of the 9th Symposium on Engineering Problems of Fusion Research to be held this October in Chicago.

Mr. YOUNG. Dr. Douglas Koop. Dr. Koop, you may proceed in any manner you would like and your statement will be printed in the record.

## STATEMENT OF DR. DOUGLAS A KOOP, MANAGER, ADVANCED PLANNING, AIRCO SUPERCONDUCTORS

Dr. KOOP. I thank the chairman and the subcommittee for this opportunity to express the views and specific concerns of an industrial participant in the fusion program.

AIRCO Superconductors is a department of AIRCO, Inc., a multidivision company headquartered in New Jersey having sales in excess of $1 billion.

AIRCO Superconductors is committed to the development and large-scale manufacturing of the superconductors required for advanced energy development programs funded by the Department of Energy.

On October 7, 1980, Congress overwhelmingly enacted the Magnetic Fusion Energy Engineering Act of 1980—Public Law 96-386.

In addition to promoting the acceleration of the current magnetic fusion research and development program through commercial development and operation of a fusion engineering device based upon the best available confinement concept, the act also includes mandates to promote the broad participation of industry in the magnetic fusion program and to maintain the United States as the world leader in magnetic fusion.

We submit that these objectives can be accomplished only through the establishment of a strong industrial base having the capability to design and manufacture the various high technology components.

The three principal plasma confinement concepts under evaluation by DOE (Tokamak, mirror, and Elmo Bumpy Torus) all require superconducting magnets. In these very sophisticated magnets, the superconductor is a highly conductive component which replaces the copper windings used in conventional electromagnets and present day experimental fusion devices such as Doublet III, Alcator-C, and the Tokamak Fusion Test Reactor (TFTR).

The unique electrical properties of superconductors are obtained only at the extremely low temperatures provided by liquid helium refrigeration. It is generally acknowledged that the technical and economic goals of magnetic fusion devices can only be attained through the use of superconducting magnets.

AIRCO Superconductors has developed and supplied large quantities of superconductors to the Mirror Fusion Test Facility (MFTF), large coil program, and other DOE magnetic fusion energy programs.

It is very important for the subcommittee to understand that extensive facilities are required to reliably manufacture the quantities of superconductors needed for these large magnets. These facilities are also required for magnetohydrodynamic (MHD) power generation, high-energy physics accelerators, energy storage magnets, and other defense-related superconducting devices.

It is our contention that the superconductors needed for construction of a magnetic fusion energy device can only be obtained from companies that have the complementary capabilities of producing prototype quantities and scaling up to deliver production quantities. The ability to handle large superconductor procurement contracts can only be provided by industrial units that have the necessary infrastructure—that is, engineering, manufacturing, planning, administration, quality assurance, financial resources, et cetera; to manufacture quality superconductors at costs and delivery rates which are compatible with program budgets and construction schedules.

An example is the prototype-to-construction transition for the Isabelle superconducting accelerator at Brookhaven National Laboratory in which AIRCO Superconductors demonstrated its capability to deliver the large quantities of superconductors for construction of the magnets.

The industrial capability to support the superconductor needs of the magnetic fusion energy program will be built over a number of years of sustained planning. The specific superconductor requirements will be identified and appropiate investments will provide the needed equipment and personnel.

AIRCO's planning for its superconductor business is premised upon the levels of funding and the timetable contemplated by the Magnetic Fusion Energy Engineering Act. This act calls for a doubling of funding within 7 years and a 25-percent increase in funding for each of fiscal year 1982 and fiscal year 1983.

We believe it to be critical to the continuation of our operations that the plans for the Fusion Energy Device and the Center for Fusion Engineering proceed in accordance with the timetable spelled out in the act. If the timetable and levels of funding called for by the act are not observed, we cannot identify any significant magnetic fusion superconductor requirements beyond the fiscal years 1980–83 needs of MFTF–B and EBT–P.

AIRCO Superconductors has the world's largest facilities dedicated to the manufacturing of superconductors. We have invested $8 million in establishing these facilities and capabilities and employ 100 people in a modern 100,000 square foot building.

This new venture was established by AIRCO with a view toward obtaining an adequate return on investment as the magnetic fusion energy program advanced into commercial development. However, we are dependent upon sustained funding to allow an orderly and logical development of our operations.

The administration has recognized the role of Government in supporting longer term, high-risk research and development which industry cannot reasonably be expected to undertake. We submit that the magnetic fusion energy program fully meets these criteria.

In order to maintain our capability to provide quality superconductors, we require a steady volume of business and a high plant utilization to economically sustain our operations. Any unanticipated changes in our business level due to budgetary cuts, funding delays, rescheduling or cancellation of programs have immediate effects on our operations.

Recent specific examples which have resulted in reductions of our work force include cancellation of portions of the 12 Tesla toroidal field coil project for the engineering test facility and superconductor procurement delays in the Brookhaven accelerator program.

Our superconductor operations are not yet profitable. However, we foresee that through careful planning, timely investments in equipment and personnel, and sustained funding of the magnetic fusion energy program, the commercialization of fusion will evolve and an equitable return on investment will be realized.

AIRCO Superconductors has extensive capability to offer to the demonstration of technical feasibility and commercialization of magnetic fusion energy. The Government must understand, however, that if industry is not encouraged to continue its participation, the Nation will not have the large-scale capability available when it is needed.

We believe that the direction and increased funding levels proposed by the Magnetic Fusion Energy Engineering Act of 1980 is the right way to proceed to a timely and efficient achievement of fusion energy, and any lessening of the pace will have a serious effect on industry's ability to participate as a full partner.

In recent years, several large corporations have entered the superconductor business and departed because the benefits were outweighed by the high business risks. Backed by 10 years of demonstrated commitment and experience, AIRCO Superconductors has the capability to reliably support the superconductor needs of the magnetic fusion energy program and I fervently solicit the support of the chairman and this subcommittee in maintaining an appropriate fiscal year 1982 funding level for magnetic fusion energy so that this capability can be retained.

I would also like to emphasize that it will be extremely difficult to maintain the United States as the world leader in magnetic fusion, in view of the substantial commitments of Government to developing a fusion industry in Japan. If this rate of Japanese industrial development in magnetic fusion is unchallenged by the United States, we may quite literally be buying our fusion components from Japan in addition to steel, automobiles, and television sets, with the implication being that this would continue to occur in the magnetic fusion energy program.

I cordially invite all members of the subcommittee to visit our facilities.

Mr. Chairman and members, I would be pleased to respond to any questions the subcommittee may have.

[The prepared statement of Dr. Koop follows:]

# STATEMENT OF DR. DOUGLAS A. KOOP
AIRCO SUPERCONDUCTORS
BEFORE THE
ENERGY RESEARCH AND PRODUCTION SUBCOMMITTEE
OF THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

March 3, 1981

Madam Chairman, I am Dr. Douglas A. Koop, Manager of Planning for Airco Superconductors in Carteret, New Jersey. Airco Superconductors is a Department of Airco, Inc., a multi-division company headquartered in New Jersey having sales in excess of one billion dollars. Airco Superconductors is committed to the development and large scale manufacturing of the superconductors required for advanced energy development programs funded by the Department of Energy. I thank the Chairman and the Subcommittee for the opportunity to express the views of an industrial participant within the magnetic fusion energy program.

On October 7, 1980, Congress overwhelmingly enacted the "Magnetic Fusion Energy Engineering Act of 1980" (Public Law 96-386). In addition to promoting the acceleration of the current magnetic fusion research and development program through commercial development and operation of a fusion engineering device based upon the best available confinement concept, the Act also includes mandates to promote the broad participation of industry in the magnetic fusion program and to maintain the United States as the world leader in magnetic fusion. We submit that these objectives can be accomplished only through the establishment of a strong industrial base having the capability to design and manufacture the various high technology components.

The three principal plasma confinement concepts under evaluation by DOE (tokamak, mirror, and Elmo Bumpy Torus) all require superconducting magnets. In these very sophisticated magnets, the superconductor is a highly conductive component which replaces the copper windings used in conventional electromagnets and present day experimental fusion devices such as Doublet III, Alcator-C, and the Tokamak Fusion Test Reactor (TFTR). The unique electrical properties of superconductors are obtained only at the extremely low temperatures provided by liquid helium refrigeration. It is generally acknowledged that the technical and economic goals of magnetic fusion devices can only be attained through the use of superconducting magnets. Airco Superconductors has developed and supplied large quantities of superconductors to the Mirror Fusion Test Facility (MFTF), Large Coil Program, and other DOE magnetic fusion energy programs.

It is very important for the Subcommittee to understand that extensive facilities are required to reliably manufacture the quantities of superconductors needed for these large magnets. These facilities are also required for magnetohydrodynamic (MHD) power generation, high energy physics accelerators, energy storage magnets, and other defense-related superconducting devices. It is our contention that the superconductors needed for construction of a magnetic fusion energy device can only be obtained from companies that have the complementary capabilities of producing prototype quantities and scaling up to deliver production quantities. The ability to handle large superconductor procurement contracts can only be provided by industrial units that have the necessary infrastructure (i.e. engineering, manufacturing, planning, administration, quality assurance, financial resources, etc.) to manufacture quality superconductors at costs and delivery rates which are compatible with program budgets and construction schedules. An example is the prototype-to-construction transition for the Isabelle superconducting accelerator at Brookhaven National Laboratory in which Airco Superconductors demonstrated its capability to deliver the large quantities of superconductors for construction of the magnets.

The industrial capability to support the superconductor needs of the magnetic fusion energy program will be built over a number of years of sustained planning. The specific superconductor requirements will be identified and appropriate investments will provide the needed equipment and personnel. Airco's planning for its superconductor business is premised upon the levels of funding and the timetable contemplated by the Magnetic Fusion Energy Engineering Act. This Act calls for a doubling of funding within seven years and a 25 percent increase in funding for each of FY 82 and FY 83. We believe it to be critical to the continuation of our operations that the plans for the Fusion Energy Device and the Center for Fusion Engineering proceed in accordance with the timetable spelled out in the Act. If the timetable and levels of funding called for by the Act are not observed, we cannot identify any significant magnetic fusion superconductor requirements beyond the FY 80-83 needs of MFTF-B and EBT-P.

Airco Superconductors has the world's largest facilities dedicated to the manufacturing of superconductors. We have invested $8 million in establishing these facilities and capabilities and employ 100 people in a modern 100,000 square foot building. This new venture was established by Airco with a view towards obtaining an adequate return on investment as the magnetic fusion energy program advanced into commercial development. However, we are dependent upon sustained funding to allow an orderly and logical development of our operations. The Administration has recognized the role of government in supporting longer-term, high-risk research and development which industry cannot reasonbly be expected to undertake. We submit that the magnetic fusion energy program fully meets these criteria.

In order to maintain our capability to provide quality superconductors, we require a steady volume of business and a high plant utilization to economically sustain our operations. Any unanticipated changes in our business level due to budgetary cuts, funding delays, re-scheduling or cancellation of programs have immediate effects on our operations. Recent specific examples which have resulted in reductions of our work force include cancellation of portions of the 12 Tesla Toroidal Field Coil project for the Engineering Test Facility and superconductor procurement delays in the Brookhaven accelerator program. Our superconductor operations are not yet profitable. However, we foresee that through careful planning, timely investments in equipment and personnel, and sustained funding of the magnetic fusion energy program, the commercialization of fusion will evolve and an equitable return on investment will be realized.

Airco Superconductors has extensive capability to offer to the demonstration of technical feasibility and commercialization of magnetic fusion energy. The government must understand, however, that if industry is not encouraged to continue its participation, the nation will not have the large scale capability available when it is needed. We believe that the direction and increased funding levels proposed by the Magnetic Fusion Energy Engineering Act of 1980 is the right way to proceed to a timely and efficient achievement of fusion energy, and any lessening of the pace will have a serious effect on industry's ability to participate as a full partner.

In recent years, several large corporations have entered the superconductor business and departed because the benefits were outweighed by the high business risks. Backed by ten years of demonstrated commitment and experience, Airco Superconductors has the capability to reliably support the superconductor needs of the magnetic fusion energy program and I fervently solicit the support of the Chairman and this Subcommittee in maintaining an appropriate FY 82 funding level for magnetic fusion energy so that this capability can be retained.

I would also like to emphasize that it will be extremely difficult to maintain the United States as the world leader in magnetic fusion, in view of the substantial commitments of government to developing a fusion industry in Japan. If this rate of Japanese industrial development in magnetic fusion is unchallenged by the United States, we may quite literally be buying our fusion components from Japan in addition to steel, automobiles, and television sets.

I thank the Chairman and this Subcommittee for the opportunity to express our concern over the possible reduction of FY 82 funding levels from those called for in the Magnetic Fusion Energy Engineering Act of 1980, and the implications such a reduction would have for continued industrial participation in the magnetic fusion energy program. I cordially invite all members of the Subcommittee to visit our facilities.

Madam Chairman and members of the Subcommittee, this concludes my prepared remarks. I would be pleased to respond to any questions the Subcommittee may have.

Mr. YOUNG. Thank you.

Representative Hollenbeck was here for a few minutes but had to leave.

I would like to at this point recognize the gentleman from California, Mr. Lowery, who is a member of our subcommittee.

Mr. LOWERY. Thank you.

Mr. YOUNG. We will now proceed with Mr. Latham.

Mr. Latham, without objection your full statement will be put in the record and you may summarize as you wish.

## STATEMENT OF THOMAS S. LATHAM, CHIEF, FUSION ENGINEERING AND TECHNOLOGIES, UNITED TECHNOLOGIES RESEARCH CENTER

Mr. LATHAM. Thank you, Mr. Chairman. I am speaking in my capacity as a member of the Atomic Industrial Forum and the testimony has been prepared and submitted. I would like to summarize some of the key points that the committee came to in their investigation.

We have found that the Magnetic Fusion Engineering Act of 1980 is well grounded in the program's scientific progress and covers the requisite points for achieving confirmation of the engineering feasibility of magnetic confinement fusion. It is realistic in its expectations and deserves the continued support of Congress.

In looking to the long-term future for our energy sources, only three main candidates have been identified: The fission breeder, fusion, and solar.

Of these three potential energy sources, the fission breeder and fusion are best suited to baseload electric power generation. The technology for the fission breeder is much further advanced than fusion power, but has not had an opportunity in the United States to demonstrate its commercial application.

Fusion technology is ready for engineering development, but cannot reach the commercial stage until well after the turn of the century.

We believe both the fission breeder and fusion should be developed as rapidly as the technology permits to confirm their potential for meeting our long-term energy needs.

Three factors are basic to the considerations of the electric utilities in the selection of an energy source; that is, its technical development, its economics as compared with other options, and its environmental impact. At this stage fusion has significant potential in all three factors.

In 1979 the AIF Committee reviewed the fusion program to examine how industrial participation can be brought about in a timely and orderly way.

In a broader sense, the AIF Committee's report addressed the basic problem of providing policy and institutional continuity to a program in which the energy payoffs will not be realized for several decades.

The AIF Committee found in its report that the scientific evidence is in hand for magnetic fusion to proceed to engineering development. This will necessitate, as recognized in the Magnetic Fusion Engineering Act, expansion of the present program to encompass a major engineering and technology development effort.

Last year the AIF Committee examined the organization and management issues raised in the Magnetic Fusion Engineering Act of 1980 to suggest an approach for coming to grips with this complex and challenging question.

I have copies of the AIF Committee paper entitled, "A Report on the Organization and Management of Fusion Engineering" with me, and if there are no objections, Mr. Chairman, I would like to introduce a copy into the record.

[The material referred to follows:]

# A Report on the Organization and Management of Fusion Engineering

Prepared by
The Atomic Industrial Forum
Committee on Fusion

January 20, 1981

Atomic Industrial Forum, Inc.
7101 Wisconsin Avenue
Washington, D.C. 20014

### Introduction

Congress recently enacted legislation, "The Magnetic Fusion Engineering Act of 1980" calling for initiation of a major engineering effort in the magnetic fusion program. The goal of the legislation is to have a demonstration fusion power plant in operation by the turn of the century. Such an effort, estimated to cost $20 billion, will require a national commitment. Achieving that goal will provide the nation and the world with an inexhaustible energy source for commercial deployment in the 21st century.

As a first step in this major engineering effort, the legislation calls for the establishment of a Center for Fusion Engineering (CFE) to serve as the focal point for engineering development. Centerpiece of the facility and initial focus of its activities will be a Fusion Engineering Device (FED). The design and construction of the FED will serve to demonstrate the engineering feasibility of magnetic fusion and, combined with the results of its operation, help define the course toward the national goal of operating a demonstration plant by the end of the century.

The legislation does not specify how such an effort can best be organized and managed but directs the Department of Energy (DOE) to submit a report to Congress by July 1, 1981 on establishment of the engineering center and associated program management. It is the purpose of this AIF Committee on Fusion* report to examine some of the issues raised and to suggest an approach for coming to grips with this complex and challenging question.

### Findings

In weighing various alternatives, the Committee found that:

- Establishment of a center for fusion engineering is an essential step toward the commercial development of fusion energy.
- The primary objective of the CFE should be the achievement of safe, reliable, environmentally compatible, and economically competitive fusion electric power and other fusion alternatives for energy application.
- Priority attention should be directed by government toward defining the scope, authority and responsibilities of the projected Center as an essential prerequisite to deciding how the Center should be organized and managed.
- To this end, the government, in concert with industry, should:
  - develop criteria for the CFE, including the scope of its activities, its responsibilities, and its authority.
  - determine the approach to be taken, based on these criteria, for organization of the Center and selection of its management.
- Criteria for the CFE might appropriately include:
  - Planning and directing a staged development program that will demonstrate sound engineering features for a commercial power reactor system. This development program should not be limited to the Tokamak concept and should include other feasible approaches.
  - Undertaking as an initial step and focal point in this process, the design, construction and operation of a fusion engineering device to demonstrate engineering feasibility and test components suitable for integration in successive systems leading to a demonstration plant by the year 2000.
  - Establishing an engineering development program, on and off the CFE site, to assure proper program balance for commercial development.
  - Pacing the program to minimize the total cost of development.
- Single line authority for both programmatic and contracting aspects of the engineering effort should be clearly vested in the CFE.
- This authority should be vested and exercised at a government level commensurate with the scale and importance of a national undertaking involving the commitment of $20 billion over a 20-year period.
- Siting of the CFE should be given priority so as to establish a firm basis for planning in those organizations from which the key individuals necessary to staff the center and carry out its mission will be drawn.
- CFE management, in turn, should have responsibility for developing the requirements for the projected FED and for selecting, on a competitive bid basis, a prime industrial contractor for the design, construction, and installation of the device at the Center. CFE management should be the final arbiter on the FED conceptual design.
- The FED should be located at the CFE site to facilitate effective management.
- Mechanisms need to be provided for active input to the CFE from the utilities as ultimate users of the technology and from the national laboratories where much of the experience in the physics aspects resides.

### Discussion

A primary motivation for enactment of the legislation is the consensus within the fusion community that the demonstration of fusion's scientific feasibility is virtually at hand, as evidenced by recent successes in the research program. It is now time to move into a major engineering program which can build upon this scientific success. This effort should be directed toward building and operating a plant by the end of this century that can demonstrate the practical application of fusion energy and serve as a precursor to economically viable powerplants for deployment in the next century.

This challenging task will require a commitment to marshal the necessary resources from all sectors, especially industry, and the national laboratories and universities. This will mean finding committed organizations and key people with the required talents and experience, wherever they may be, and vesting in them the authority, responsibility, and resources needed to carry out the task successfully.

By its very nature, most of the experience in mounting and managing large and complex engineering projects resides within industry. With commercial application not expected until well after the turn of the century, industry's contribution will be primarily through commitment of its resources, experience, and skilled people rather than through substantial monetary outlays. The top management of industrial companies must carefully weigh the commitment of these resources against competing demands in other areas, many of which may offer earlier return on investment. Critical to such commitment on the part of industrial management is confidence that the effort taken in mounting the fusion engineering program will continue to receive the support and resources from government to see the program through to a successful conclusion.

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*The members of the Committee on Fusion are listed in Appendix I of this report.

### Transition to Engineering

As noted in this Committee's earlier report, the launching of a major engineering effort requires a successful transition from primary emphasis on physics, which has characterized the fusion program to date, to emphasis on engineering development, supported by a strong and continuing physics program. This transition will be a difficult one and will mandate a series of conscious policy changes to be carried out effectively. Moreover, as directed in the legislation, it will require a programmatic shift and change in location of the ongoing engineering effort into a separate activity.

It is important that the scope and role of the separate activity, which is identified as the Center for Fusion Engineering, be spelled out carefully before final judgments are made on arrangements for organization and management of the engineering program.

### The Evolution of the Center for Fusion Engineering and the Fusion Engineering Device

In its initial phases, the discussion within government on mounting a major engineering effort for magnetic fusion centered on what was termed an engineering test facility (ETF). As originally visualized, the device in that facility represented substantial extrapolations of the physics and engineering parameters in existing devices. The Fusion Review Panel chaired by S. J. Buchsbaum of DOE's Energy Research Advisory Board concluded* that the risks associated with incorporating such extrapolations into one device were unacceptably high and recommended the construction of a less ambitious device which would be more likely to meet its technological and cost objectives.

Further, the panel thought that the concept of an engineering test device by itself was too narrow an approach to the broader problems associated with mounting a successful engineering development program for fusion. It recommended that a center for fusion engineering (CFE) be set up to undertake this broader task and that the more modest device it had recommended, the Fusion Engineering Device (FED) be constructed at the center as the focal point for its initial activities. This approach was incorporated in the legislation and has been adopted as official policy by DOE.

It is important to recognize that in the evolution of policy between the original ETF concept and the CFE/FED approach recommended by the Buchsbaum panel, commercial fusion power was removed as a primary goal of the engineering program. The more limited capability of the FED as compared with the ETF will result in the need for increased emphasis on the successive steps beyond the FED which would be necessary to achieve the demo objective. These program elements should be addressed promptly, together with their estimated costs and time scales.

### Considerations in Weighing Organization and Management Alternatives

In weighing alternative approaches to the organization and management of the projected engineering center, the Committee believes it important to recognize that the characteristics and requirements of the commercial environment for fusion power are markedly different from those which exist in situations where government is the ultimate customer of the product, such as in space or defense. It is essential, therefore, that those concerned with the economic as well as technical viability in the marketplace be actively involved from the early stages of the development process and that this process be oriented from the beginning toward the goal of commercialization.

Pursuit of this goal requires that the organization and management of a complex undertaking such as the engineering development of fusion power be mounted in a way which will permit the achievement of this objective in an orderly and cost effective manner. Equally important is establishment from the beginning of appropriate relationships among those who will be charged with carrying out this task and those who will be responsible for distributing the ultimate product to the American consumer.

It is recognized that the development of fusion energy for ultimate commercial application is still at an early stage. Physics problems remain to be solved, the technology is still being developed, and the precise characteristics of the device to be incorporated in an operating fusion powerplant are as yet unknown. Nor is there any certainty that the next major step — development of an engineering testbed to demonstrate engineering feasibility and test components — will lead directly to the design of a commercially viable powerplant.

Nevertheless, despite these uncertainties, the success of the major engineering effort about to be mounted will depend in considerable measure on how well the program is oriented toward the goal of ultimate commercialization and its inherent requirements. The approach and structure of the program, including a workable relationship among the major participants, must be tailored accordingly. Conversely, if program orientation and structure are developed in an environment where the government comes to be viewed as the customer of the product and program objectives are formulated on a roll-forward basis as the program progresses, then certain consequences necessarily follow.

These include a tendency for the government, particularly where it is providing the lion's share of the funding, to assume technical direction of the effort and for the goals of that effort to be diffused toward developing information as an end in itself, rather than tied to commercialization objectives. Without the disciplines inherent in the latter, there is high risk that commercilization goals will never be achieved and that costs will escalate beyond politically acceptable levels. There is ample evidence for this contention in a study performed several years ago by the Rand Corporation* on cooperative projects undertaken in the past by industry and government.

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*Report on the Department of Energy Magnetic Fusion Program prepared by the Fusion Review Panel of the Energy Research Advisory Board, August 1980.

Another difficulty in building a healthy industrial base is the perceived reluctance on the part of DOE to award follow-on business to firms that participated in prior concept definition studies. This reluctance appears to stem from policies and procedures in the DOE procurement process which tend to exclude those firms with prior involvement. This situation could be remedied in large measure if, in its procurement practices, DOE were to follow the provisions of OMB Circular A-109, "Major Systems Acquisition," which establishes policies to be adopted by Executive Branch agencies in the acquisition of major systems. Steps to implement this policy should be taken now.

## Organization and Management Approaches

In reaching its findings and conclusions, the Committee evaluated the following organization and management approaches for the CFE:

- **Solicitation of Competitive Proposals**

  In this approach, management of the Center for Fusion Engineering would be selected by solicitation of competitive proposals from the major sectors of private industry. The winner of this competition could be a single entity i.e., a manufacturing company, architect-engineer-constructor, etc., or some combination of these organizations. The CFE management would have responsibility for construction and operation of the FED, for other engineering test facilities, and for coordinating all engineering activities in the magnetic fusion program. It would inherit all of the preconceptual design work on an engineering device performed by the present design center at Oak Ridge and would have responsibility for developing an RFP to industry for conceptual design of the device. The arrangement for transfer of the design work already accomplished would not limit the flexibility of the CFE management in developing a final design. After evaluating the responses, the CFE management would make its selection in concert with its governing organization, and successive design and construction activity would then proceed through industrial contracts with the engineering center. Whoever is selected to manage the CFE would presumably be precluded from bidding on the prime contract for design and construction of the FED because of conflict of interest, but would be permitted to bid on subcontracts involving the manufacture of system components. Some parallels to this approach are found in the procedures used in selecting the organization to build and operate the Elmo Bumby Torus Proof of Principle EBT(P) device.

- **Special Project Office**

  A variation of this approach would call for establishment of CFE management by competitive bid and then setting up a separate parallel special project office, either in Washington or in the field, to oversee the design and construction of the FED. The CFE would retain responsibility for coordinating the overall fusion engineering program and would lend support to the special project office in the R&D associated with design and construction of the device. The special project office, as in defense and space programs, would be abolished once construction and check-out were completed and the CFE assumed responsibility for operation of the device. This concept is comparable to those Special Project offices established in the Apollo program.

- **Corporate Entity Concept**

  This approach would establish the CFE as a separate corporate entity, possibly under Congressional charter, and charge it with carrying on the fusion engineering program through the demonstration phase. This would include responsibility for design and construction of the FED, contracted out to the private sector on a competitive basis; for the supporting R&D program on and off-site; and for guiding the program through the successive steps necessary to reach the demonstration plant stage by the turn of the century.

  A board of directors, appointed by the President, would be responsible for the operation of the CFE. The board would be comprised of senior level individuals experienced in the management of large engineering projects and drawn from the major institutions involved, including the utilities, architect-engineers, industrial firms, the universities, and the national laboratories. A line management organization headed by an executive director vested with appropriate authority and responsibility to carry out the center's mission, would be established under the direction of the board. Models of this concept which suggest possible avenues for further consideration are Comsat and the recently established Synfuels Corporation.

- **Partnership Arrangements**

  Distinguished from the above corporate concept are several examples from the past where corporate bodies, in the form of industry-sponsored organizations, entered into partnership arrangements with the government to advance fission energy for power production:

  — In the Shippingport model, technology developed for submarine reactors was applied to commercial usage through industrial contractors under the technical direction of the government.

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*Analysis of Federally Funded Demonstration Projects: Final Report (The Rand Corporation, R-1926, Doc, Santa Monica, California, 1976)

- In the Yankee-Rowe demonstration plant regional electric utilities provided the technical direction and contracted the work to industrial architect-engineer and equipment supplier firms through normal commercial channels.
- In the liquid metal fast breeder program, the electric utilities established the Breeder Reactor Corporation to serve as a vehicle for financial contributions to the program and a Project Management Corporation for carrying out the Clinch River breeder project, in concert with the government.
- In the helium fast breeder reactor, a utility-sponsored body, Helium Breeder Associates was organized to act as the developer and "surrogate owner" of a helium fast breeder. Under this concept the utilities, as ultimate users of the technology, assumed technical direction and management of the program, provided guidance on development work to be contracted out to the private sector, and in concert with government, arranged for active participation of the national laboratories. Removal of government support in the past year has placed a hold on the program.
- In a similar joint effort an electric utility sponsored group, Gas Cooled Reactor Associates, is proceeding in its program designed to advance technology for the high temperature gas-cooled reactor.

**Conclusion**

Effective organization and management of the major engineering effort on which the magnetic fusion program is about to embark are critical to solving the complex problems inherent in taking a technology which is just now emerging from the laboratory and advancing it to engineering practice. To accomplish this, the Committee concludes, based on its findings and the considerations weighed in this report, that:

- The objective of the CFE should be the timely development of fusion electric power and other alternatives for energy application.
- Successful accomplishment of this objective will require vesting in the CFE single line authority for both programmatic and contracting aspects of the engineering effort.
- The role and scope of the CFE should include responsibility and authority for planning and directing fusion engineering development, for establishing an engineering development program on and off-site, and for designing, constructing, and operating the FED. An essential first step is to define clearly the detailed role and scope of CFE activities to serve as a basis for organization and management planning.
- The government, in concert with industry, should:
  - Develop criteria for the CFE, including the scope of its activities, its responsibilities, and its authority.
  - Determine the approach to be taken, based on these criteria, for organization of the Center and selection of its management.
- The fusion engineering device should be located on the CFE site.

The Committee stands ready to assist in the challenging task of developing criteria, defining the role of the CFE, and establishing an organizational and management framework which can bring into being a demonstration fusion power plant by the turn of the century.

## APPENDIX I
## FUSION COMMITTEE MEMBERS

Chairman: Sidney Law
Director of Research
Northeast Utilities

Secretary: Frank W. Graham
Special Studies Manager
Atomic Industrial Forum, Inc.

**William O. Allen
Advanced Physical Processes
Development Manager
Bechtel National, Inc.

W. B. Allred
Consulting Engineer
Stone & Webster Engineering Corporation

Clinton P. Ashworth
Supervising Mechanical Engineer
Pacific Gas & Electric Company

**G. Edwin Brown, Jr.
Management Consultant

Sibley C. Burnett
Manager, Fusion Program
Development Department
General Atomic Company

R. Bryan Cairns
Advanced Technology Manager
Boeing Engineering and Construction Company

Colin S. Caldwell
Scientist of Material Technology Laboratory
Lynchburg Research Center
The Babcock & Wilcox Company

Ralph S. Cooper
Deputy Director
Radiation Physics Division
Physics International Company

Howard R. Drew
Executive Vice President
Texas Atomic Energy Research Foundation and Texas Utilities Services, Inc.

**Edward C. Fiss
Senior Staff Consultant
Advanced Generation Concepts
Duke Power Company

William A. Frederick
Manager — Advanced Projects
Pennsylvania Power & Light Co.

*Harold K. Forsen
President
Jersey Nuclear-Avco Isotopes, Inc.

Robert W. Goodrich
Senior Scientist
Northeast Utilities

E. R. Hottenstein
Manager, Advanced Technology
Gilbert Associates

Henry Hurwitz
Physicist
General Electric Research and Development Center

**Thomas S. Latham
Chief, Fusion Engineering and Technology
United Technologies Research Center

James A. Maniscalco
Manager — Fusion Energy Systems
Advanced Technology Laboratory
TRW, Inc.

Albert B. Martin
Program Manager
Fusion Programs, Energy Systems Group
Rockwell International

Kenneth L. Matson
Vice President
PSE&G Research Corporation

Frederick J. Milford
Associate Director for Research
Battelle Columbus Laboratories

**Alfred E. Munier
Director of Advanced Energy Systems
Grumman Aerospace Corporation

N. Thomas Olson
Senior Staff Scientist
Maxwell Laboratories

**Leonard F. C. Reichle
Executive Vice President
Ebasco Services, Inc.

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*Chairman, Subcommittee on Organization and Management of Fusion Engineering.
**Member, Subcommittee on Organization and Management of Fusion Engineering.

Peter Rose
President
Mathematical Sciences
Northwest, Inc.

Carl H. Rosner
Chairman and Chief Executive
Intermagnetics General Corporation

Gunnar E. Sarsten
Vice President — Power Division
United Engineers and Constructors, Inc.

**Zalman M. Shapiro
Manager
Westinghouse Fusion Power Systems

Charles L. Storrs
Director, Advanced Development
C-E Power Systems
Combustion Engineering, Inc.

Alvin W. Trivelpiece
Corporate Vice President
Science Applications, Inc.

Mr. LATHAM. The paper recognizes that proceeding to the engineering phase of fusion power development will require a commitment to marshal the necessary resources from all sectors, especially industry, and the national laboratories and universities. This will mean finding committee organizations and key people with the required talents and experience, wherever they may be, and vesting in them the authority, responsibility, and resources needed to carry out the task successfully.

By its very nature, most of the experience in monitoring and managing large and complex engineering projects resides within industry. With a commercial market not expected until well after the turn of the century, industry's contribution will be primarily through commitment of its resources, experience, and skilled people rather than through substantial monetary outlays.

The top management of industrial companies must carefully weigh the commitment of these resources against competing demands in other areas, many of which offer earlier return in investment. Critical to such commitment on the part of industrial management is confidence that the effort taken in mounting the fusion engineering program will continue to receive the support and resources from Government to see the program through to a successful conclusion.

I can report for my own company, United Technologies Corp., which is representative of the industry, that we support a major fusion engineering effort.

We recognize that the transition from primary emphasis in physics, which has characterized the fusion program to date, to emphasis on engineering development will be difficult. It will require, as noted in the legislation, a programmatic shift and change in location of an expanded engineering effort into a separate activity.

Effective organization and management of this effort are critical to solving the complex problems inherent in taking a technology, which is just now emerging from the laboratory, and advancing it to engineering practice. The AIF Committee report addresses these issues.

In closing, I would like to reiterate the primary points I have made for your consideration.

One, that there is a consensus within the fusion community and industry that the demonstration of fusion scientific feasibility is virtually at hand.

Two, that the Magnetic Fusion Engineering Act is correct in its premise that it is now time to move into a major engineering program which can build upon the scientific success.

Three, that industry is ready to commit its key people and experience to support a major engineering effort.

We believe that our future energy needs and the state of magnetic fusion development supports the 25-percent increase in funding in fiscal year 1982, that the Congress found in the legislation would be required. Any delay in moving into the engineering phase would drive the ultimate cost of the program with only a small compensating decrease in the development risks.

The progress in magnetic fusion development is currently limited by available funds rather than technical barriers. We would urge that the subcommittee support the 25-percent increase in funding for the magnetic fusion program in fiscal year 1981.

Mr. Chairman, this concludes my prepared remarks. I would be pleased to try to answer any questions you or the subcommittee members may have.

Thank you.

[The prepared statement of Mr. Latham follows:]

AIF Committee on Fusion
Testimony by Thomas S. Latham
Before the Subcommittee on Energy Research and Production
of the Committee on Science and Technology
U.S. House of Representatives
March 3, 1981

Thank you, Madam Chairman. I am Thomas S. Latham, Chief, Fusion Engineering and Technology, United Technologies Research Center, and a member of the Atomic Industrial Forum's Committee on Fusion. It is in my capacity as a member of the AIF Committee on Fusion that I am appearing before you today.

As you know, the Atomic Industrial Forum is an international trade association with over 600 member organizations. It is dedicated to the peaceful use of nuclear energy for mankind's needs in energy, medicine, and industrial development. The member organizations of the AIF include electric utilities, architect-engineers, equipment manufacturers, mining and milling companies, labor unions, laboratories, financial institutions, and universities. Over 100 of the member organizations are outside the United States.

First, let me thank you for this opportunity to present the views of the AIF Committee on Fusion on expansion of the U.S. magnetic fusion program to encompass a major engineering and technology development effort. I want to commend you, Madam Chairman, and the other members of this Subcommittee for your foresight in recognizing the need for accelerated development of this promising energy source.

We have found that "The Magnetic Fusion Engineering Act of 1980" is well grounded in the program's scientific progress and covers the requisite points for achieving confirmation of the engineering feasibility of magnetic confinement fusion. It is realistic in its expectations and deserves the continued support of Congress.

In looking to the long term future for our energy sources, only three main candidates have been identified: the fission breeder, fusion, and solar. Of these three potential energy sources, the fission breeder and fusion are best suited to base load electric power generation. The technology for the fission breeder is much further advanced than fusion power, but has not had an opportunity in the United States to demonstrate its commercial application. Fusion technology is ready for engineering development, but cannot reach the commercial stage until well after the turn of the century. We believe both the fission breeder and fusion should be developed as rapidly as the technology permits to confirm their potential for meeting our long term energy needs.

Three factors are basic to the considerations of the electric utilities in the selection of an energy source, i.e., its technical development, its economics as compared with other options, and its environmental impact. At this stage fusion has significant potential in all three factors.

In 1979 the AIF Committee reviewed the fusion program to examine how industrial participation can be brought about in a timely and orderly way. In a broader sense, the AIF Committee's report addressed the basic problem of providing policy and institutional continuity to a program in which the energy payoffs will not be realized for several decades.

The AIF Committee found in its report that the scientific evidence is in hand for magnetic fusion to proceed to engineering development. This will necessitate, as recognized in the Magnetic Fusion Engineering Act, expansion of the present program to encompass a major engineering and technology development effort.

Last year the AIF Committee examined the organization and management issues raised in "The Magnetic Fusion Engineering Act of 1980" to suggest an approach for coming to grips with this complex and challenging question. I have copies of the AIF Committee paper entitled, "A Report on the Organization and Management of Fusion Engineering" with me, and if there are no objections, Madam Chairman, I would like to introduce a copy into the record.

The paper recognizes that proceeding to the engineering phase of fusion power development will require a commitment to marshall the necessary resources from all sectors, especially industry, and the national laboratories and universities. This will mean finding committee organizations and key people with the required talents and experience, wherever they may be, and vesting in them the authority, responsibility, and resources needed to carry out the task successfully.

By its very nature, most of the experience in monitoring and managing large and complex engineering projects resides within industry. With a commercial market not expected until well after the turn of the century, industry's contribution will be primarily through commitment of its resources, experience, and skilled people rather than through substantial monetary outlays. The top management of industrial companies must carefully weigh the commitment of these resources against competing demands in other areas, many of which offer earlier return in investment. Critical to such commitment on the part of industrial management is confidence that the effort taken in mounting the fusion engineering program will continue to receive the support and resources from government to see the program through to a successful conclusion.

I can report for my own company, which is representative of the industry, that we support a major fusion engineering effort.

We recognize that the transition from primary emphasis in physics, which has characterized the fusion program to date, to emphasis on engineering development will be difficult. It will require, as noted in the legislation, a programmatic shift and change in location of an expanded engineering effort into a separate activity.

Effective organization and management of this effort are critical to solving the complex problems inherent in taking a technology, which is just now emerging from the laboratory, and advancing it to engineering practice. The AIF Committee report addresses these issues.

In closing, I would like to reiterate the primary points I have made for your consideration.

- That there is a consensus within the fusion community and industry that the demonstration of fusion scientific feasibility is virtually at hand.
- That The Magnetic Fusion Engineering Act is correct in its premise that it is now time to move into a major engineering program which can build upon the scientific success.
- That industry is ready to commit its key people and experience to support a major engineering effort.

We believe that our future energy needs and the state of magnetic fusion development supports the 25% increase in funding in fiscal year 1982, that the Congress found in the legislation would be required. Any delay in moving into the engineering phase would drive up the ultimate cost of the program with only a small compensating decrease in the development risks.

The progress in magnetic fusion development is currently limited by available funds rather than technical barriers. We would urge that this Subcommittee support the 25% increase in funding for the magnetic fusion program in fiscal year 1982.

Madam Chairman, this concludes my prepared remarks. I would be pleased to try to answer any questions you or the Subcommittee members may have.

Mr. **Young**. Thank you, Mr. Latham.

We will now proceed with some questions. I think as we go through the panel I might ask a few questions and other subcommittee members will do the same thing.

Dr. Dean, is the magnetic fusion program scientifically ready to move forward into the engineering development phase?

How can one tell when you will be ready to go?

Dr. **Dean**. I can say several things. One, you can't cleanly separate the scientific from engineering in this program. A lot of engineering had to be done in order to make the accomplishment in science that we have gotten to date. If we are going to move forward, we have to continue to do engineering and science together. So it is a shift in emphasis and it is bringing in a new community, especially in industry, to do some of the really heavy engineering that will allow us to make continued progress.

I think the simple answer is, yes, fusion is ready for an increased component of engineering that will allow us to move the whole program forward to a more practical system.

Mr. **Young**. Thank you.

Mr. Blattner, in order for fusion engineering devices to be operating by 1990, what must we do in 1982, fiscal year 1982, to assure that this 1990 date is still viable?

Mr. **Blattner**. Mr. Chairman, we have taken a look at this and compared it to the facts in some of the space and missile programs we have had. We believe it does take 7 years beginning with preliminary design through installation and checkout. If you back off about 7 years, by 1982 you should be ready to institute the preliminary design. The critical path for components will then have to be identified and the development, with experiments, will have to be laid out. The Center for fusion engineering, that will have this responsibility, will have to be in 1982 to make a 1990 date.

Mr. **Young**. Thank you.

Dr. Miley, I was very interested in your testimony. What do you feel that Congress can do to contribute so that the universities will be funded at a rate consistent with the advancement of the fusion program in general?

I notice that out of 100 outstanding candidates for graduate fellowships in fusion there were I think you said, only 6 fellowships available. That all ties in, but what can we do right now to assure that the universities will be ready to help us as we move into the engineering technology phase of the fusion program?

Dr. **Miley**. Well, that is a complex question. I think there has to be a partnership between the mission agencies, State agencies, industry, and the universities in order to meet what turns out to be a very severe monetary problem and people problem. The key role of the universities in both research and manpower development has to be recognized by the other poartners. Both fellowship programs and research programs must be supported.

I believe that providing a stable base for research, therefore providing continuity of support, is one of the most crucial aspects of all this. One frustration that has driven faculty from universities is that they end up with students that are working with them on a research topic that requires 3 to 5 years of work but they are funded on a 1-year basis, often with funding being turned on and off like a water spigot. So a research support policy that provides stability needs to be established as well as a sound fiscal base.

Mr. YOUNG. At the present time, what major universities have fusion engineering programs?

Can you give us an idea?

Dr. MILEY. I can start with the University of Illinois, since I am familiar with that.

Mr. YOUNG. How about the University of Missouri?

Dr. MILEY. They made a wise move in that they recently hired two of our people and they are moving ahead! Both the University of Missouri at Columbia, and at Rolla have started programs in fusion engineering. Other examples include MIT, the University of Michigan, the University of Wisconsin, and, moving west, the University of California at Berkeley, and UCLA.

Mr. YOUNG. Don't most State universities usually have a program?

Dr. MILEY. Not really. As I noted earlier, participation in the DOE fellowship program indicates there are only 11 universities that currently have major ongoing programs. I suspect there are 25 more that are trying to develop programs. If additional support if given, they should be able to come on strong, given time.

Mr. YOUNG. Thank you.

Mr. Latham, what has been United Technologies' role in the fusion program?

Mr. LATHAM. United Technologies' role dates back to the late fifties when at our research center we began a physics research program on fusion. That program has continued until about 1 year ago.

Around 5 years ago we entered the technology field principally with the design and construction of the Texas Experimental Tokamak at the University of Texas in Austin. More recently, we have been working on neutral beam hardware development by applying technology developed for high-energy laser systems and jet engines to fusion problems.

This, application of high technology to fusion problems is an area in which industrial participation is most fruitful.

I would like to speak to continuity and momentum, if I may.

Mr. YOUNG. Yes.

Mr. LATHAM. These comments support what George Miley has just said. If this the magnetic fusion development venture is to succeed you must attract the hearts and minds of key people in industry, and sustain the momentum of the program.

It is our experience that with oscillating support people drop out of programs such as this and you never retrieve them. Consistent financial and programmatic support must be a key consideration. An ambitious project such as the fusion engineering device is an excellent objective that can be simply described and understood, but the momentum must be maintained at a high level or you will have personal and industrial participation problems.

Mr. YOUNG. Thank you, Mr. Latham.

Mr. Lujan.

Mr. LUJAN. Thank you, Mr. Chairman.

At a previous committee meeting, or almost every one I go to everywhere is always talking about cuts. Just to put that in perspective, we are not talking about cuts, as a matter of fact, but it depends on how you view them.

Under last year's program, fusion received about $394 million and this year DOE is talking about $460 million and OMB is talking about $475 million, and our budget talks about $500 million, so if you are talking about cutting from the high figure, then you would have some cuts, but when you take an additional 25 percent, which is an additional $100 million to keep it moving, the figure that OMB is talking about, which is $75 million more, that is pretty close to $100 million.

If the same thing holds true as in the past, if things go in reverse, saying we will win, nobody seems to talk about lowering the money, but they always seem to win. I have confidence in their thinking they will win.

Isn't the $475 million about the range that you are talking about?

Mr. LATHAM. I really don't wish to speak to the numbers precisely.

Mr. LUJAN. You just said in order to keep a viable program we needed a 25-percent increase.

Mr. LATHAM. This was the AIF Committee's recommendation with regard to the 1982 budget. My earlier comments were addressed to beyond 1982 and maintaining a momentum that ultimately calls for, in real dollars, a doubling of the current fusion budget.

I think that needs to be recognized as the long-range requirement.

Mr. LUJAN. In real dollars, it means a lot of difference anyway. We are set on keeping inflation down and the present day dollars might be a lot closer to real dollars.

Would the $475 million keep the university program going?

Mr. MILEY. I don't know. As seen from the numbers I quoted to you earlier, the university's role in fusion engineering is an emerging field. It needs to be expanded rapidly if we are to develop the manpower that is needed in the near future.

I have no knowledge as to how the future DOE moneys are going to be used relative to universities. The fellowship program was the first signal that serious consideration has been given to the university's role. The money you speak of, would be most valuable if proper thought is given to how to effectively involve the universities in the expanded R. & D. programs.

Mr. LUJAN. Yes. We have a problem. We feel that mandate as Members of Congress in running for reelection every 2 years that the country is telling us to be careful how you spend money.

I am an advocate of pursuing the future program, that seems a little better than most anybody else will be doing.

Dr. MILEY. In the engineering area, figures being quoted next door in the NSF hearing indicate a multibillion deficit in funding for universities at the graduate level. This represents a severe manpower plus facilities shortfall. With fusion being a forefront technology which needs to enter this arena, I would say that the numbers you are quoting are still too low to provide an impact on graduate education that will get the fusion manpower we are going to need.

Mr. LUJAN. What would you think the number should be?

Dr. MILEY. A precise number is difficult to cite without more study.

Mr. LUJAN. Let's go back to $394 million.

Dr. MILEY. Let's talk in terms of students. The universities supplied something like 20 fusion engineers last year, but it looks like the need in only a few years will be a factor of five higher. If DOE expands its fusion engineering effort according to the 1980 Fusion Energy Act, I think we are in an order of magnitude off in manpower supply. Thus we are roughly an order of magnitude off in university support.

Mr. LUJAN. Increasing by a factor of five?

Dr. MILEY. Five times in the near future, with further increases to match later expansion.

Mr. LUJAN. When I gave an opening statement, one of the things I had to think about was whether we keep on the present course, if we keep on the present course, is there a better way or less expensive way of doing it?

We are charging full speed ahead on Tokamak and we are talking about, what, $600 million for the engineering facilities?

Dr. MILEY. Yes, as I understand it.

Mr. LUJAN. Well, we are heading in that direction. Let's suppose that the answer would lie in the inertial confinement reactor in the future, then we wouldn't need it, do we?

Are we to the point that the answer is in magnetic fusion and not in the inertial confinement reactor?

Dr. DEAN. I would like to comment on that.

This field has a richness and variety of concepts. It is sometimes confusing for people to try to pick winners out of it. I think you have to look at it in a different way. This wouldn't come to practical application until 20 years from now. We are in a phase right now of doing an awful lot of physics and science and an awful lot of engineering and technology and not speaking of commercial reactors and it is inappropriate to pick out whether it is the Tokamak or inertial confinement reactor and this is not the time to try to answer that question.

You cannot without grave danger, it seems to me, without cutting out the ultimate winner, try to make that selection right now. At some level you have to keep these things coming along and nurturing them.

I think the point is, whoever builds the first fusion reactor which makes a lot of power, Tokamak, or whatever, you are going to learn one hell of a lot about materials and how to handle fusion energy and what the nature of the problem of fusion is and it may be preceded by inertial or some other kind, but you won't be sorry when you build that first one just like the Wright brothers were not sorry when they built their first plane.

We have to move ahead with what we got and Tokamak is ready and it is sort of the flagship of the future and that is the way you have to look at it.

Dr. KOOP. If I may, I would like to go back to your previous question of whether $475 million was enough?

From our viewpoint as an industrial concern trying to commence operation of a separate commercial unit within a large corporation and concurrently trying to convince our corporate management that there is a future in this high-technology area, we do not think it is enough.

One of the basic reasons that we feel the funding level is too low is that although the support within industry is growing, most of the money is still expended within the national laboratories.

In order to participate in this technology and contribute in a meaningful way you need a certain critical size to develop the prototypes and scaleups I mentioned. We (that is, AIRCO Superconductors) have that critical size, but that critical size is a lot of square feet and a lot of people and we need to be kept busy. We need to keep that whole facility utilized.

Unless we do see more expenditures out in industry, it will be exceedingly difficult to cover our operating cost so that we can continue our participation. We don't expect to make any money, by the way, for a long time. I also share one of Dr. Miley's concerns. We have a real problem in industry when we want to staff up, with experienced people, because it is very difficult to find qualified people and this problem will worsen.

Mr. LUJAN. What you are saying is, the only way to keep the kind of availability of industry there for the time when it is needed is to keep the Federal bucks flowing?

Dr. KOOP. Yes.

I might also say at the present time it is not clear to us whether the $475 million includes funding for the FED and the Center for Fusion Engineering. We are very concerned what is out there beyond the next 3 years.

Mr. LUJAN. A 20-percent increase, do you realize that?

Dr. KOOP. It is, sir, and we think the program requires it. The program cannot advance without the participation of companies like mine and some of the other gentlemen here.

I think there is a lot of capability in the American private sector and we are ready. We don't expect to make a lot of money on it and, as I said, we will be happy to recover [illegible] costs.

Any way you look at it, it is an expensive proposition.

Mr. LUJAN. Mr. Blattner.

Mr. BLATTNER. I cannot really address the whole budget but I believe 475 would not be enough, if in the course of that expenditure you didn't proceed with FED and EBT-P. We have been building up a head of steam for 7 years. We built up our activity greatly 3 years ago in commitments to EBT and we committed our corporation to buying land and construction of facilities. We are willing to spend our resources now in parallel with those of the Government for the good of the program and for the long-term gain we will make.

Mr. LUJAN. Let me look at it another way.

I don't want to say we get lulled by the fight between the breeder and fusion, which seems to be the problem, but if you look at it optimistically, if you put that much into fusion to bring it on in 1990 or the year 2000, then in reality what is the future of the breeder if you can have generation by fusion?

Dr. DEAN. My view of that is that it is not appropriate for us here, or yourself, to try to make that technical judgment at this time.

Mr. LUJAN. Just fund them all?

Dr. DEAN. You have to bring them along and let the marketplace do its thing, it seems to me.

You don't want the Government to dictate, "This is the way we are going to do it," if it is not the best way from a commercial point of view. The technology you have to develop for fusion and fission is not something which the Government is going to commercialize.

I don't think, either fusion or fission should be severely cut back to pursue the other. I don't think that is appropriate. If you have to make a compromise then bring them both along more slowly. I don't think it would be appropriate to pick between them because I think it is too soon to know which will make it in the commercial market.

Mr. LUJAN. When can we decide between technologies?

Dr. DEAN. I have a comment as to that issue. That is, from the point of view of utilities and the national interest, we can ill afford not to bring along our evaluations, if you will, of say the breeder and fusion far enough so we can make a very sufficient judgment as to economic viability, environmental impacts, and all other considerations that have to do with important power-producing capacity of the United States.

If we back away from a promising technology and we discover too late that other nations of the world, for example, have discovered that fusion is viable, then I think in the long run we will suffer greatly.

Mr. LUJAN. I agree with you, except with this change in economic times I cannot be sure we can go full speed ahead. That is my personal way of looking at it, having to focus on funds for all of the programs.

It would be great if we could just fund everything at the level that it should be funded. We are going to have to look at it.

Dr. DEAN. I think that is true and I think you will make the judgment appropriately and we have confidence in your doing it. But I urge that, in the process of making that judgment, don't go along with a policy judgment that we should put fusion on the back burner and hold it in a scientific state for the next 4 years. Let fusion go ahead with engineering development at whatever budget level you gentlemen can come up with within the bounds of your priorities.

Mr. LUJAN. Thank you.

Dr. MILEY. On the breeder, I would like to add that a mistake was made in the sense of turning the program off while thinking that we could turn it back on when needed. Clearly we have lost our leadership in that area, and I hope you don't make the same mistake in fusion.

Mr. YOUNG. Mr. Lowery.

Mr. LOWERY. Thank you, Mr. Chairman.

We do have a distinguished panel of people before us. I guess the basic problem is that we only have finite resources available. Let me put this question to you. What is the most promising technology at this point in terms of fusion breeder reactors, and so on, what are we looking at in terms of both money and time? I know it is a hard question, but in terms of time the question is what should we give up?

Don't all answer at once. If each of you could comment, I would appreciate it.

Dr. KOOP. Congressman Lowery, that is a very difficult question to answer, because I am not an expert in all of the technologies being considered here. I can only offer my opinion regarding fusion technology and the effects of funding limitation on industrial participation.

I think we need a more aggressive approach because you reach a point where there is some type of cost-benefit as to how much you study something.

We have developed, as I have testified, a wide range of superconductors and not all of them, as is well known in the community, have been truly classified or accepted as engineering materials. The only way we can do that is to go forward and build a superconducting device such as the fusion engineering device. That is the only way that we can find out whether some of these materials will really work from an engineering stance. I don't think that really addresses the full measure of your question.

Mr. LOWERY. Is there an appropriate amount of funding to put the breeder device on line?

Dr. KOOP. No, sir. I think you need greater participation of industry. I don't think the device can succeed without industry. More expenditures in industries are required.

We also need the current and probably growing participation of national laboratories because we have to work together. I think we have worked together quite effectively in recent years. I think you need to expand the industrial sector but not at the expense of the national laboratories.

Mr. LOWERY. At what cost?

Dr. KOOP. I can't tell you what it is going to cost, sir.

From our studies, we feel that the levels proposed by the Magnetic Fusion Energy Act are about right. We think we can continue our participation at those levels. We think it is not too fast, but it is not too slow. I can't give you an exact level.

Dr. DEAN. With the Fusion Act DOE concluded last year that to implement the program you had to have a doubling of the program over the next several years. There was some difference as to whether it should be over the next 3 or 5 or 7 years.

The point is there has to be growth and you have to encourage momentum and bring in a new set of players to add to the existing set; namely, the private sector and the engineering technology companies. The direction in which to move and commitment to move in that direction is more important than arguing over whether the budget should be $460 million or $500 million or whether the budget doubles over 3 years or it doubles over 7 years.

Mr. LOWERY. Thank you.

Dr. DEAN. I think your excellent staff is probably better qualified than we are to help you work out the detailed numbers for the programs.

Mr. LOWERY. I know we have advocates of fusion. Mr. Latham, has the Atomic Industrial Forum taken a position in terms of the priority of fusion and the breeder, and so on?

Mr. LATHAM. No. I think their position at the moment is that each of these technologies needs to be taken far enough so that you have solid commercial, technical, and environmental impact data on which to make your choice. That is why I think your question is so difficult.

Mr. LOWERY. I know.

Mr. LATHAM. None of those systems have been brought far enough in our view to make all those evaluations.

Mr. LOWERY. When do you think optimistically we could start making these decisions and what dollar investment to get there?

Mr. LATHAM. Here, I have to speak to the Magnetic Fusion Engineering Act, because I am really not qualified to speak about the fission systems, but I believe the act was realistic in the assumption that it would require 20 years and $20 billion to advanced magnetic fusion to a demonstration which would yield some information on which to base some economic, technical, and environmental evaluations.

Mr. LOWERY. Twenty years and $20 billion and do you think that is realistic?

What stage would we be in in the year 2000 on fusion? Would it be viable at that point?

Mr. LATHAM. No. I think the first engineering demonstration would be completed, but there would still be a more extenstive a data base to be developed for economic evaluation beyond that.

Mr. LOWERY. Thank you.

Dr. KOOP. Congressman, I don't think you can really begin to make the choice between fission and fusion without at least having built the fusion engineering device.

Mr. LOWERY. I think there is a great deal of promise in the area of fusion and we are probably not doing as much as we could. The question as we all know, is how much we can afford, faced with all of the pressures of today, not alone two decades down the road.

I happen to believe the advances in the world have been due to our technological superiority, but we are rapidly losing that, and have in the years past, across the board, but it is tough to make a decision as to whether you fund everything a little bit or you make a decision, right or wrong, and forge ahead just as rapidly as we can.

Thank you.

Mr. YOUNG. Do any members of the panel have any final comments before we close?

Dr. Miley.

Dr. MILEY. I want to go back to the breeder-fusion question. As the head of the engineering department, and working on both, I must say I believe in coexistence. I just feel that both represent such fundamental attacks on our long-range energy problem that we can't afford a controversy between the two which is purely a monetary conflict. When you look at the time scales, the questions, the status of the present development, they are also quite different. I think we have to tighten our belts and keep developing both on a timely basis.

Mr. YOUNG. Are there any other additional comments?

[No response.]

Then, on behalf of the committee and Mrs. Bouquard, I want to thank you very much for appearing here this afternoon and giving us a better understanding of the readiness of the fusion program. We need your input so we can try to make the right decisions in the very, very near future.

On behalf of the Subcommittee and the full committee I want to thank you very much for your participation this afternoon.

Mr. DEAN. Thank you for having us.

[Whereupon, at 3:20 p.m., the subcommittee adjourned.]

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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WEDNESDAY MARCH 4, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 9:30 a.m., in room 2325, Rayburn House Office Building, Hon. Marilyn Lloyd Bouquard (chairman of the subcommittee) presiding.

Mrs. Bouquard. The committee will come to order.

Good morning, ladies and gentlemen. Today we will be hearing testimony on a nuclear program that is very important, but controversial. For 4 years running the Congress was involved annually in shoot-outs at Clinch River with the Carter administration. I have had a unique role to play in this controversy because the Clinch River breeder reactor project is in my district in Tennessee, and I am very proud to have been actively involved in this issue. I am pleased about the strong support that the project has received from this subcommittee.

This project remains an important symbol of this Nation's commitment to realistic energy supply. It is tragic that the previous administration continually attempted to terminate the project. Although the Clinch River breeder reactor project has survived, much money and, of course, much time has been wasted. I am looking forward to a positive climate for the breeder program in the 97th Congress. The nonproliferation arguments, the pessimistic forecast of electrical demand, and the petty economic arguments are now history. We must move ahead with the breeder program and we must sort out the very best way of using our national resources and our talent in achieving the goal of demonstrating the viability of this marvelous technology.

We have a very distinguished panel before us this morning, and we also have with us a voice of opposition to this project. I can assure everyone that we will move ahead with reason and proper deliberation, but we do certainly intend to move ahead with this program.

At this time I would like to ask unanimous consent that the cameras be permitted in the hearing room. Without objection, it is so ordered.

Our panel this morning is composed of Mr. Floyd Culler, President of the Electric Power Research Institute and a former constituent of mine whom I still claim, Mr. Sam Iacobellis, president of the Energy Systems Group, Dr. John Yasinsky, is general manager of the Advanced Power Systems Divisions of Westinghouse

Electric Corp, and Mr. John Kearney, who is vice president of energy and environmental activities, Edison Electric Institute. After the panel, Dr. Thomas Cochran of the Natural Resources Defense Council will share his views on this subject with the subcommittee.

Gentlemen, please proceed with your testimony.

## STATEMENT OF FLOYD L. CULLER, ON BEHALF OF ELECTRIC POWER RESEARCH INSTITUTE

Mr. CULLER. Thank you, Madam Chairman.

I am Floyd Culler, president of the Electric Power Research Institute, which most of you know is a nonprofit organization established in 1973 by the electric utilities of the United States to perform research, development, and demonstration of new power systems. Until 3 years ago, I worked in various capacities at the Oak Ridge National Laboratory for 33 years, and I have a reasonably detailed knowledge of breeder reactors in the United States and foreign breeder programs because of this association.

I very much appreciate the opportunity to emphasize the need for fast breeders in the United States, to comment about past U.S. efforts, and to propose ways to reactivate the stalled U.S. breeder effort.

Madam Chairman, it had been suggested by the staff that I prepare a brief introduction describing breeders and a little bit about the program. I think from the committee's standpoint, most of you have heard this preamble, and if you wish, I will skip the two or three pages of thought about background on breeders in general and proceed. You may choose either way.

Mrs. BOUQUARD. Please proceed. Any of you who would like to summarize your statements, I can assure you that your full statement will be made a part of the record. So proceed with your testimony as you see fit,

Mr. CULLER. I had anticipated perhaps some newer members on the committee, but I think most of the members here are familiar with breeder technology, and I will skip that.

Mrs. BOUQUARD. I would like to welcome Mr. Volkmer, our distinguished Representative from the State of Missouri, who is not a new member of the committee. We are awfully happy to have him, as well as our distinguished colleague from Michigan, Mr. Wolpe.

Mr. CULLER. The breeder reactors now being developed are predominantly based on the plutonium-fueled and sodium-cooled liquid metal fast breeder concept. Several medium-size 250–600 MWe demonstration plants operate today, and additional larger-size plants are proposed or are under contruction. Two other high-gain breeder concepts, the gas-cooled fast reactor and the molten salt breeder, have not progressed much beyond small-scale experiments.

The light water breeder reactor, of course, is in a different class. It is not a high-gain breeder and continues under investigation in the Department of Energy.

The main development trend of the industrial nations has been the reactor progression from the LWR to the fast breeder reactor. Plutonium produced in the present light water reactor will be used to stock the breeders as they are deployed and proven to be reliable power and fuel producers, likely, at our present pace, to be some time after the year 2000.

All breeders require fuel reprocessing and a closed fuel recycle. At present, reprocessing and recycling activities are not permitted in the United States. This ban, of course, is a major obstacle in the long run to the breeder, since the breeder cycle requires plutonium and the unconsumed $U^{238}$ to be recycled back to the reactor after removing a small fraction of plutonium which is the breeding gain. If you remember, breeders produce more fuel than they consume, and it is this small fraction that is removed in the recycle, laid up over the years, and in anywhere from 15 to 25 years it will be possible to accumulate enough plutonium to stock another reactor. That is known as the doubling time.

Several European nations are already committed to breeders of demonstration scale and will no doubt use the technology as a commercial power source in the near term. Dr. Sam Iacobellis will discuss the foreign breeder program later on this morning in greater detail.

The future of the breeder reactor in the United States clearly depends on national energy policy. If a large-scale demonstration program were to begin soon, and could maintain a steady development pace, the breeder option could be available for possible use only a little before 2000, or perhaps a little later.

The U.S. breeder program started well before 1950. The first electricity generated by nuclear power was produced by the Experimental Breeder Reactor-I at the Idaho Reactor Test Station in 1951. In truth, the early concepts for commercial nuclear power were, among those of us who worked on these programs early, centered around breeders. The uranium isotope separation processes were so successful that it was possible to build economically competitive, water-cooled enriched fuel reactors, not only for the naval submarine program but also for commercial power.

The water technology for steam generation was a familiar one to the electric utilities at that time, as of course it is now. This combination of familiar technology and economics was decidingly in favor of proceeding with LWR's. The die was cast by about 1957, when the first utility consortia selected water reactors as the types to be developed first. Breeders were planned to follow to use the plutonium generated by these water reactors for the period when natural uranium supplies finally restricted the availability of the scarce but fissionable uranium-235 isotope.

Thus, the breeder stepped into line as a successor, rather than the predecessor, to LWR's. With breeders it will be possible to produce electricity for tens of thousands of years, and I stress this point: The breeder is a continuing energy source. This is possible of course because the breeders use all the uranium in natural uranium and are about 60 to 70 times more efficient than LWR converters.

Breeders are considered as essential for a long-term nuclear program by the utilities, as a continuing system for energy supply as natural uranium is depleted. Studies performed by the National Academy of Science and the National Academy of Engineering, and all other professional studies, concluded that breeders should be available as an option for slowly expanding use sometime around the turn of the century. And this timing is reasonably agreed to by all. The point in the development program is that it will take us as long as 20 years at a steady pace to demonstrate the breeder program.

Most responsible reviews of the future need for energy conclude that nuclear power is essential to meet the minimum electricity supply for the United States and the world. Current estimates of total energy required by the United States in 2000 A.D. are for about 105 to 120 quads—we are now using somewhere around 80 quads—assuming a population at the year 2000 of 260 million, a work force of 135 million, up from 96 million in the labor force today. Assuming that coal production can expand by about a factor of 3 in 20 years, and additional measures can be enacted over those now in effect to save 25 to 30 percent of current energy demand, and with optimistic credits for energy production for solar, wind, geothermal, and biomass, a minimum of 300 reactors of 1,000 megawatts each will be needed in the United States to maintain employment at about 94 or 95 percent of the work force. These estimates indicate that it is highly likely that energy supply will constrain the economy. We do not see a superabundance of energy in the latter 10 years of this century since it is probable the economy will be constrained by the cost of energy or the supply of energy itself.

The leadtime to provide a workable breeder system is at least 20 years. Thus, it will not be possible to deploy breeders for large-scale use before about the turn of the century. To be in a position to use breeders we need to start a steadily paced program of the breeder option within the next year or so.

The objectives of a reactivated breeder development program in the United States should include: Construction and operation of the liquid metal fast breeder reactor and fuel recycle demonstration plants should proceed at a pace to provide a commercial breeder for possible deployment in the late 1990's. Breeder designs and fuel recycle services suitable for worldwide use should be prepared. The breeder program should include necessary safety features, of course, to protect the public. Appropriate regulatory procedures, standards, and organizations must be established in the Nuclear Regulatory Commission and the EPA.

To achieve these objectives, it is desirable that the U.S. breeder program be reactivated now to prevent further serious erosion of skills and manufacturing knowledge. It is important, too, that the United States reestablish its role in breeder development internationally, to allow beneficial acquisition of knowledge on breeders and processes from other nations who are now operating and building reactors.

We urge that the United States adopt and consider the elements of the following program, these elements to be undertaken somewhat simultaneously, and not sequentially because we now are beginning to feel the pinch of time. The first part of an action plan would be to complete the Clinch River breeder reactor as a research and test reactor. Such construction should be completed as soon as possible. We would suggest that it be required that expeditious licensing action be taken, recognizing the advanced status of licensing for CRBR before construction was stopped in 1977. We suggest too that for the CRBR the loop design should be retained because it provides a versatile system for testing of improved pumps, steam generators, controls, and fuel bundles at reasonably significant engineering scale. The CRBR, under present schedules, would go critical perhaps in 1990, although we hope that these schedules could be improved.

The second element of the plan, and a very important one, because the CRBR is not enough to demonstrate breeder technology—the second element would be to initiate planning and design for a large prototype LMFBR. The initial phase should be the design, but with an explicit commitment to build, starting construction perhaps around 1986 or a little later.

I note that foreign participation in this program should be considered. The possibility of joint programs with appropriate groups in other nations should be studied immediately. There is a practical urgency to decide this issue because of the specific interest on the part of Great Britain to proceed with their breeder program. They have decided, as has Japan in all probability, that it is desirable for them to proceed in a cooperative, committed demonstration effort. The first stage, which would include design and cost estimates, would probably be sufficient for an initial commitment for cooperative work. A second decision can be made when design is finished regarding commitments to construction; this second-stage decision would occur perhaps in 1983 or 1984.

This morning I had breakfast with Michel Picaird, who is in charge of the French program. The French continue to be interested in the possibilities and the discussion concerning joint programs with the United States. Not definite, not worked out, but there is a continuing interest in the possibility of engaging in joint efforts in breeder development.

The next major element of the program should be to demonstrate the fuel recycle required for breeders. A pilot-scale reprocessing and recycle fuel fabrication facility should be available to plutonium fuel for reinsertion in the large demonstration reactor and for the CRBR. And of course subject to whatever the program worked out to be in its major elements, we suggest that the Department of Energy's breeder R. & D. program be alined to (a) support the completion of the CRBR, now mostly completed in its development stages, and (b) provide support for the development of systems, equipment and data required to license and site breeders in the United States.

As I have said, there is strong utility support for completion of the CRBR and the initiation of a large demonstration breeder program, although because of present financial conditions the utilities will find it difficult to provide financial support as they have in the past. It is necessary to emphasize that CRBR alone will not make it possible for the United States to have the breeder option. The demonstration of larger scale reactors is essential, since the probable minimum economic size for a breeder is almost certainly three or four times that of CRBR.

There is strong utility interest, also, in the possibility of proceeding with a joint demonstration program with one or more foreign partners. The overall cost to each country might be significantly reduced and the skills and knowledge to produce a reactor licensable in most countries of the world would be assured.

It is likely that a multinational program would best be pursued by a private-government development corporation whose participants might be individuals from the U.S. reactor manufacturers, utilities, equipment suppliers, and appropriate government representatives. This new entity, in theory at least, could continue the demonstration program for the needed 20-year period, or longer, provided appropriate long-term financing could be arranged. At the end of the demonstration period, the development corporation could be dissolved, the participants then returning to their competitive roles as suppliers or buyers.

There are many reasons for strong support for breeders worldwide and let me sum these up. Breeders extend the limited natural uranium resource by a factor of 60 to 70 over the light water reactor. Since only small quantities of the abundant $U^{238}$ are burned to produce power in breeders, very low-grade resources such as the uranium in shales, and the Japanese say even sea water derived uranium, could be used to supply the breeder program in spite of the very high cost of uranium from these sources. It is unthinkable to use uranium from these sources in the light water reactor programs.

During the period when relatively low-cost uranium is available for LWR's, breeders deployed widely in the large industrial countries would relieve price pressure on natural uranium to favor developing nations. This was an important point in the conclusions and recommendations section of the INFCE study, the International Nuclear Fuel Cycle Evaluation study, and was put in by many of the nonindustrial country members. They recognize this as being important.

All reactors, of course, produce plutonium, as illustrated in the attached figure to your report. Plutonium from LWR's in developing nations can be used most effectively for a while to stock new breeders in the large industrial nations, thus providing a natural balance between large industrialized weapons states who need plutonium and the developing nations who can best afford natural or partially enriched fuels.

This, again, was a very strong point made in the INFCE study, saying that a balance for the developing nations about whom we are most concerned conceivably in proliferation can be maintained by this natural pull for plutonium in the industrialized and in many cases weapons states for plutonium to stock breeders.

The next point is one that is not often made. The only foreseeable available technology in this century that can place an upper limit on the cost or price of petroleum is nuclear power, and this is particularly true of breeders. Breeders are free from mining in the ground, and in Oak Ridge there are 300,000 tons of depleted uranium that will provide the fuel source for breeders for perhaps 500 to 600 years already available. Electricity from breeders is insensitive to uranium costs. In the United States there are 500 to 1,000 years' supply of depleted uranium.

The breeder, in many substantial respects, is a safer reactor than existing LWR's. And at some point in time, if you all would like to discuss this, there are many, many studies that support it.

Current estimates suggest that capital costs of the early breeders will be 1.3 to 1.4 times as much as for LWR's. The Superphenix is costing twice as much at the moment, but it is first of a kind and one of a kind. The French anticipate reducing the capital to about 1.3 times the cost of LWR's and to produce electricity at costs only 15 percent above LWR's and significantly less than coal or any other sources. And they will probably go rapidly toward breeders for this reason.

They will produce electricity at competitive costs, therefore, per kilowatt-hour, easily, by 2000 A.D. or so, because of increased uranium costs and improved breeder performance.

More important, it is likely that breeders will produce electricity at costs equal to or lower than coal-fired systems in the United States. Not necessarily competing with LWR's, but it is almost certain that breeders will produce electricity at costs competitive with coal. I should note that nuclear energy now provides the lowest cost electricity of all sources in the United States and overseas, maybe by 15 to 20 percent in the United States and 25 to 40 percent in other nations.

In summary, I urge that the breeder development and demonstration be given high priority for the turn of the century. As a prerequisite to breeders, however, solutions to very urgent problems in light water reactor systems such as radioactive waste disposal are necessary to preserve the overall nuclear option in the United States. We now have the opportunity to set things right for LWR technology and to move vigorously to demonstrate fission breeders, so vital to our energy supply and future well-being.

Thank you.

Mrs. BOUQUARD. Thank you very much, Floyd, for your very valuable testimony.

I would like to recognize now my distinguished colleague from California, the Honorable Barry Goldwater, who will introduce our next panelist.

Mr. GOLDWATER. Thank you, Madam Chairman.

We are very pleased to have this opportunity to hear testimony from individuals who have been involved in the development of the breeder reactor and can share with us considerable insight as to where we go from here. This obviously is a long-ignored question that must be addressed. Definitive decisions must be made. All of these gentlemen who are appearing before us have been involved in and agonized over this problem not only because they themselves have an interest, but those that they represent have had dollars on the line. And I think we owe this country the service to make some decisions.

One of those individuals who resides in my congressional district is Sam Iacobellis, president of the Energy Systems Group. He is an individual whom I have grown to respect and admire for his intelligent, balanced approach to energy problems.

The Rockwell Co. obviously is a multibillion-dollar company that gets involved in all kinds of things, and one of those very important areas is the field of energy. It has used its technology derived from the space program, from military programs, and other technical efforts in behalf of its stockholders by applying it to the problems of energy, not only nuclear energy, but certainly also solar energy and geothermal energy. All kinds of difficult problems involving materiels. And Sam, I just want to on behalf of the committee, welcome you again. You have been before this subcommittee many times and have made major contributions. We look forward to your testimony.

Mrs. BOUQUARD. Sam, before you begin your testimony, I would like to recognize the ranking Republican member of our subcommittee, Mr. Lujan. Do you have any opening remarks at this time?

Mr. LUJAN. Not really, Madam Chairman. Thank you very much for recognizing me. I look forward to seeing where we are with the breeder, what direction we ought to be going in. And I am just interested in what is going on.

Mrs. BOUQUARD. Thank you very much.

Please proceed with your testimony.

## STATEMENT OF SAM F. IACOBELLIS ON BEHALF OF ENERGY SYSTEMS GROUP, ROCKWELL INTERNATIONAL

Mr. IACOBELLIS. Thank you, Madam Chairman, and Congressman Goldwater for that introduction.

I am Sam Iacobellis, president of the Energy Systems Group of Rockwell International.

Rockwell is actively engaged in essentially all of the energy production areas including nuclear, fossil, and the renewable sources. In the nuclear area, we are an associate reactor manufacturer for the Clinch River project and one of the prime contractors to the Department of Energy conducting the conceptual design study of the large developmental plant.

Over the past few years, I have had the privilege of testifying before you on the breeder program. On each of these occasions, I have emphasized Rockwell's strong support for the breeder and, in particular, the Clinch River breeder reactor project. I am pleased to be invited here again.

It goes without saying that I would have preferred to address this group after having seen the new administration's revised 1982 budget, but I understand your tight turn around schedule prevents that sequence.

I have been asked to give a personal brief overview of the present U.S. and international LMFBR programs and the status of component development. By way of qualification, I have been privileged to be a member of the U.S. LMFBR coordinating committees with France, with the Federal Republic of Germany, the United Kingdom, U.S.S.R., and Japan for the past 7 years. As a member of these five committees, I have had the opportunity on numerous occasions to personally visit and inspect all of the major LMFBR existing facilities and plants under construction in these countries.

Congress is to be commended on its steadfast support of the U.S. breeder program over the past two decades and, in particular, over the past 4 years when there were those who called for a termination of the Clinch River project and a considerable reduction of breeder support. I will not attempt to review all past testimony that Congress has received on the need for the breeder, but I believe that one preeminent fact should be repeated:

The United States has already mined, for its military and commercial nuclear projects, over 300,000 tons of uranium. Less than 1 percent of this material has been utilized in these projects. The remaining material is called depleted uranium or uranium tails. The material has no further use in these programs and is currently being stored at the Government's enrichment plants. Utilizing this material in breeder reactors, and without mining another pound of uranium, is equivalent to 2.4 trillion barrels of oil, which is more than three times the world's proven recoverable oil reserves, or twice the amount of recoverable U.S. coal reserve. This is a $72 trillion fuel resource if equated to oil at only $30 each barrel. This is a national unused energy resource worth more than $300,000 to every American citizen.

As the price of oil continues to rise, as world tension continues to increase because of dwindling oil reserves, as the Nation continues to conserve and utilize all of its resources to maintain an adequate energy supply for the future, and as we struggle to mend our economy, this vast potential of the breeder should not and cannot be forgotten. The development of our breeder technology to utilize this national resource should not be further delayed.

I will now attempt to summarize for you where the United States stands in relation to the foreign LMFBR programs, with particular emphasis on components, and I will offer a recommendation to set our program back on track.

The base technology has been extensively developed over the past 35 years. Liquid metal components have been tested, and experimental demonstration, development, and commercial reactors have been constructed and operated.

Fifteen LMFBR plants have been constructed and operated throughout the world. There are currently 11 sodium-cooled fast reactors in operation. Four more are scheduled to go critical by 1985. Altogether, the world's LMFBR's have accumulated more than 100 reactor-years of experience. These reactors have produced over 3 million megawatt-hours of thermal energy, of which 90 percent has been produced abroad. The addendum to my statement that the subcommittee received this morning graphically reflects the forward commitment to the LMFBR.

The Soviet Union, in addition to its three breeders in operation, brought its 600 megawatt BN-600 on line last year and has decided to proceed with 1,600 megawatt LMFBR plants for replicate deployment in the 1990's.

In France, in addition to their highly successful 250-megawatt Phenix plant which has been supplying power to their utility grid since 1973, the construction of the 1,200-megawatt Superphenix-I is well advanced. This plant is being financed by the Governments of France, Italy, and Germany. Initial sodium fill is scheduled for 1982 and criticality in 1983. Electricite de France is currently designing an advanced version of Superphenix rated at 1,500 megawatts and plans to order these plants in pairs by 1985. France's President Valery Giscard d'Estaing recognizes the importance of the breeder to their national energy independence. He has said:

> If uranium from French soil is used in fast breeder reactors, we will have potential energy reserves comparable to those of Saudi Arabia.

The Japanese, whose experimental breeder reactor, Joyo, went critical in April 1977, are proceeding with the design and construction of the 300 megawatt Monju plant.

By the way, the word Joyo in Japanese means eternal light.

In the United States, meanwhile, we continue to fall further behind in a field that we once dominated. The question of our being forced, ultimately, to turn to others for LMFBR technology has become more than rhetorical.

Fortunately, with the support of Congress, a reasonably strong basic R. & D. program was continued during the past 4 years of indecision on the Clinch River breeder project.

Our 60 megawatt experimental breeder reactor, which began operation in 1963, continues to run very well. The major LMFBR milestone in the United States last year was the criticality of the FFTF. This 400 megawatt facility is the world's preeminent fuels and materials test facility. It was brought to full power in December.

Westinghouse is the lead reactor manufacturer for the Clinch River project, and GE and Rockwell International are major subcontractors on the project. Burns & Roe is the plant engineer, and Stone & Webster has been chosen to be the plant constructor.

Dr. John Yasinsky of Westinghouse, who follows me, will cover the Clinch River design status, and I will concentrate on the Clinch River component status.

Specifications for major plant equipment are substantially completed and many major components have already been fabricated. To date, $124 million worth of components have been delivered including: Reactor vessel, $22.8 million; sodium dump tanks, $3.2 million; sodium pump drives, $12.6 million; intermediate heat exchanger, $38.1 million; reactor closure head risers, $2.8 million; secondary control rod drive, $6.1 million; and primary sodium overflow vessel, $2.2 million.

In addition, numerous tests have been successfully completed. The in-vessel transfer machine for refueling has successfully completed a comprehensive series of tests.

The sodium dump tanks were successfully tested by the Pittsburgh-Des Moines Steel Co. in Pittsburgh and shipped to Memphis for storage. Meanwhile, at the Byron Jackson Pump Division in Vernon, Calif., the sodium pump and pump drive system were tested in a new water test facility.

Tests on prototype units for both the primary and secondary control rod systems were conducted during fiscal year 1980. The primary and secondary control rod systems are independent and redundant systems.

The prototype steam generator being manufactured at the Rockwell facility in El Segundo, Calif., successfully completed the installation and welding of the 757 tubes and initiated closure welding of the outside shell. This unit is scheduled for completion this summer and will be tested at the DOE-owned, Rockwell-operated Energy Technology and Engineering Center's steam generator test facility at Santa Susana, Calif.

Even though CRBRP components have been progressing, the United States has continued to fall behind France and the USSR in this next phase, that of the design, construction, and testing of commercial-size components. This situation needs to be corrected; otherwise, the United States will be forced to turn to foreign suppliers for these components.

As I mentioned earlier, I have not seen the recommended LMFBR fiscal year 1982 budget; however, I recommend; one, full support of the CRBR demonstration plant; two, immediate initiation of the detailed design of the large developmental plant as defined by the conceptual design study as an approved LMFBR program element, and three, definition and authorization of a total LMFBR program.

If the Clinch River program were discontinued, breeder development in the United States would be delayed for many years. During such a time lapse, the substantial industrial base already built up and paid for would largely disappear.

This highly specialized technical team is a national resource and should not be allowed to be dispersed and lost; rather, the next step in the LMFBR development program should be initiated so that there could be a smooth transition of this team of people onto the next job. In this regard, the foreign countries have also done a superb job in providing continuity for their human resources on their LMFBR programs.

Approximately $1 billion has been invested in the Clinch River program to date. We should capitalize on this investment.

My recommendation would allow the United States to have the breeder option available on the earliest time frame, which already may be late when the additional time needed beyond the operation of the CDS-large developmental plant to bring commercial plants on utility grids is recognized.

The possibility of foreign participation in the large developmental plant should also be investigated, but I would strongly recommend this be done in parallel with the initiation of the detailed design so as to not lose the continuity of this important program while such discussions and agreements are being worked out.

I would like to point out that the Clinch River and the CDS-large developmental plants are vital but are only elements of a total LMFBR program. For that matter, they are also key elements of the conventional nuclear option, because the light water reactor option is dependent on a successful breeder program to provide an assured, long-lasting domestic fuel supply. All the foreign industrialized countries recognize this dependency.

The critical strategic elements of a total LMFBR program plan are, one, a strong R. & D. program; two, experimental testing facilities; three, power demonstration, Clinch River; four, large developmental plant; five, closed fuel cycle demonstration; six, an industrial infrastructure; and most importantly, seven, a national mandate. We need a long-term national commitment.

In summary, it is my opinion that this approach is the most effective way of getting the United States back in step on LMFBR development so that the benefits of this tremendous resource can be made available to the American public as a truly viable option at the turn of the century.

[Material referred to above follows:]

## SUPPLEMENTAL STATEMENT OF SAM F. IACOBELLIS

The breeder is a necessary part of the nuclear power option. All nations that have committed themselves to the use of nuclear-electric power, have done so with the full expectation that this course would not end in a few decades when the limited supply of fissionable Uranium-238 was exhausted, but would go on for centuries by utilizing the unique ability of the breeder reactor to increase the world's fuel supply by transforming the vast reserves of otherwise useless Uranium-238 into fissionable material.

The breeder is already a well-developed energy technology as evidenced by the 11 breeders now in operation and other near-commercial plants in construction or advanced design in Europe and Japan. What the U.S. program needs most is to actually demonstrate that we can build and operate these plants reliably on utility grids. Because of the long lead times of each step in this important demonstration, these steps must be started early and pursued in a steadfast, orderly fashion.

Mr. YOUNG. Thank you very much, Mr. Iacobellis.

We are going to break in the middle of this hearing for just a few minutes. Mr. Wolpe has to leave, and I think he has a question or two he would like to ask.

Mr. WOLPE. I thank you, Mr. Chairman, and I appreciate your courtesy.

I think I want to begin by paying tribute to our chairman of this subcommittee. I happen to be in the position of one who has some reservations, rather substantial reservations about the wisdom of the program that is under discussion today, and yet I found there is no more effective an advocate and no more tenacious an advocate than Mrs. Bouquard. And the fact that all of you enjoy such good support from this committee is very largely attributable to her effort. So I speak with enormous respect for my chairman in this instance, and I only wish that I had a different point of view. It would be much more comfortable for me.

The set of questions I would like to just throw out for consideration by the two panelists who have spoken so far do not relate specifically to the engineering questions that have been raised in previous panels and to which you have been addressing yourselves in some degree today, but rather relate to a broader set of concerns that I and I think some others have with respect to how do we go about deciding where to invest Federal research and development moneys. That is, what criterion do we use in trying to assess the wisdom of a given investment, whether it is in breeder technology or conservation or whatever the issue may be. What has been troubling to me, as I have looked at not only this question but some other questions, has been the absence, essentially, of any criterion. We tend to respond to specific proposals advanced by one or another interest.

I would submit that our major concern in this country is to try to find some way for reducing our dependence upon petroleum, particularly upon overseas petroleum. I noticed there was some reference to that as a rationale for breeder technology. I wish you could help me then understand why an investment in breeder technology is a better investment, given a scarcity, especially now, of Federal resources, given the necessity of making some very, very hard choices. As you are all aware, there are enormous cutbacks being proposed in our whole energy R. & D. budget; as well as all the other domestic programs of this Government. Why is that a better investment than an investment, for example, in the encouragement of broader conservation initiatives or some other form of investment? The reason I ask is that the end product of the Clinch River breeder reactor or breeder technology generally is electricity, and yet we find in this country that electricity is consuming only 9 to 10 percent of all of the oil that is being consumed in our country. Most of our oil is going into transportation, about 51 percent; another 18 percent or so into space heating, for which electricity is not very efficient. So it is not clear to me why we want to invest in a very highly capital-intensive technology as distinguished from investments which will much more quickly and much more cheaply displace petroleum.

Mr. CULLER. Mr. Chairman, may I reply?

Mr. YOUNG. Yes, Mr. Culler.

Mr. CULLER. The Electric Power Research Institute is basically interested, as you probably realize, in all forms of energy. As far as the utilities are concerned, it considers the solar option as valid as nuclear. And we face the same problem on a yearly basis of deciding where to put the research and development funds that are assigned to us by the utilities.

In connection with the Federal Government, EPRI spends more money in energy research than any research and development organization. As a consequence, we have a yearly exercise in which we go through and attempt to prioritize by overall broad objectives what our research and development emphasis should be. And our analytical approaches to this are available to you in what we call our overview and strategy documents, which I will be delighted to give you.

I will now sum quickly the three or four important premises that we distill out. No. 1, we find that it is reasonably essential to realize that growth will occur in the economy because of the demographic pressures that will be brought by a certain population of 260 million people in the year 2000 and a requirement for a work force of 135 million. These are Bureau of Census data.

Mr. WOLPE. Could I interrupt here on that very point?

Mr. CULLER. Yes.

Mr. WOLPE. My understanding is that the figures that have been developed by the Electric Power Research Institute have actually very recently indicated that the electrical requirements for the year 2000, for example, are going to be just about half of what had been originally indicated.

Mr. CULLER. That is true, absolutely true. We are finding that true because of the effective use of reasonable constraint in electricity and total energy use, therefore conservation is important. And I remind you that the instruments in many States and in many areas of effective conservation come through the utilities themselves. They have 1,100 programs, basically, for conservation.

We have estimated lower than before. Our estimates now are based on what we are calling a minimum economic expectation. We are saying that if the population goes to 260 million and a work force of 135 million, that the minimum that the economy should sustain is to allow everyone to stay in place in the society, no upward mobility, that would be the minimum expectation acceptable socially. No increase in personal income, no relative upward migration in the society.

Now, with the expansion of the work force by 32 percent, an average increase in the mean age from 30.4 years to 35 years and a 15-percent increase in college attendance—those are the things that we couple to get an expectation index—we find that the minimum expansion in the GNP probably is of the order of 2½ percent per year to sustain an unemployment level of about 6 percent.

Now, with this, we think that it is necessary with zero expectation to increase energy consumption in the United States by 50 percent, allowing an additional 30 percent for conservation. Every unit of energy used in industry would have to improve 35 percent in its effectiveness. We assume that 80 percent of the homes would have solar water heaters in order to get the savings in the heating sectors, in the residential sector. These overall expectations turn out, then, to say that we need perhaps 104 quad, 50 percent more than today. Now, our older estimates were made 2 years ago and 3 years ago assuming a different coupling between the economy and energy. We projected not as close a coupling. Even with the 104 quads, when we look at the space sector now we find that it is necessary to substitute for oil--first premise, substitute for oil. No. 2, do not overly constrain. Do not overly constrain. Substitute something for oil. Not necessarily electricity. Coal and nuclear are the two fuels available. We are supporting, therefore, more work in coal than we support in nuclear. We think that it is urgent that we get the electricity systems available to provide a substitute heat for residential and commercial to electricity, and are working vigorously on heat pumps that have a coefficient of performance of a factor of 3.

Mr. Wolpe. That I can understand, I must admit, much more clearly than I can understand the subject under discussion right now.

Mr. Culler. Let me tie it up quickly.

Mr. Wolpe. Fine. Let me clarify the point, because I have a feeling I may not have sharpened it sufficiently. The issue is not whether or not we should pursue an R. & D. program into breeder technology. I support that and have long supported a basic R. & D. effort to try to develop breeder technology for the future so that we can have that capability when the time comes when it is both necessary and, importantly, commercial.

The question we are raising, at least as I understand the issue when we discuss the Clinch River breeder reactor in particular, is whether this country is ready to make a commitment for the development essentially of a commercial plutonium breeder reactor. And I guess the question I am raising is: Is that not a premature commitment? Given now the much longer projection about the available uranium supplies because of a much lower rate of growth of electricity demand, given our immediate problems to try to get rid of that dependency upon petroleum, might it not be better to invest our dollars and our scarce private sector resources in those areas which will much more quickly and much more cheaply displace petroleum?

Mr. Culler. There is a balance in funding, and we spend basically less money on breeders by far in EPRI than we do on coal and LWR safety, for instance.

Now, the question that you raise of course is a good one. The answers are a little subtle. Most new technology that is introduced requires 30 years of preparation. And when the demonstration reactor of 1,000 MW is operating in the United States in 1995, that is the first point where the utility system might be willing to consider buying two units to put in place. And that would not occur until 2005, well after the year 2000. Now, in order to have the breeder option available for that period when conceivably we will find constraints on uranium supply, because the rest of the world, if the indications are true, will go more rapidly toward nuclear, in order to have the breeder available as an option for deployment, we must have a steadily paced development now of lesser priority, conceivably, than revitalizing LWR's, and certainly getting on with coal, coal synthetics, coal gasification, and conservation for the near term. But if we delay, if we delay now, without a steadily paced commitment to breeders for the option being available in the year 2000, when 2000 arrives we will not have them.

Mr. **Wolpe**. Well, I thank you. My time is exhausted, and I appreciate the courtesy extended to me. Thank you very much.

Mr. **Young**. Thank you very much.

Dr. Yasinsky, would you like to proceed? Without objection, your formal statement will be made a part of the record and then you can summarize in the way that you would like, sir.

## STATEMENT OF JOHN YASINSKY ON BEHALF OF ADVANCED POWER SYSTEMS DIVISIONS, WESTINGHOUSE ELECTRIC CORP.

Dr. **Yasinsky**. Thank you, Mr. Young, members of the subcommittee.

I would like to first thank you for providing me with the opportunity to be with you today.

I am John Yasinsky, general manager of the Advanced Power Systems Divisions of Westinghouse Electric Corp. Our company has been involved for some time now in the development of a broad spectrum of advanced energy technologies, including the breeder reactor.

I would like to comment briefly up front on the very important question that Mr. Wolpe raised, that is, what should be the criteria in identifying where we commit these funds for the future. I believe among the criteria one should consider is the degree or the magnitude of the benefits that will accrue to the Nation, looking broadly at the area of economics and national security. Secondly, we want to look at the time required to bring about that technology to the point where we can all benefit from it, as well as the amount of investment. Those key criteria indicate that the LMFBR program that did exist prior to 1977 and that we hope will exist in the future is one that should go forward and be supported.

The point made that slightly more than 10 percent of our electricity is generated from oil is true. If we also combine with that the fact that we are burning natural gas which is also a very valuable clean fuel that has unique applications, we see that almost a third of our electricity today is coming from oil and natural gas. That is not desirable.

In considering nuclear substitution for oil generated electricity we have to look at the future: How are we going to supply additional electricity in the future, specifically the increment that we will need to sustain the economy and our national security.

Also, Mr. Wolpe didn't address the very important point that we must look at the end-use area and determine where electricity can be substituted for oil and natural gas. This can make a significant difference in the future.

Mr. Wolpe indicated the need to focus on immediate problems, and I agree with that. However, we must not neglect the future. If we had acted 10, 15, or 20 years ago with wisdom and foresight, many of these immediate problems today would not be problems.

Our experience in all aspects of electric power within Westinghouse leads us to conclude that electrical substitution for oil will continue to grow—it must grow. Electricity consumption will grow almost twice as fast as total energy consumption over the next 20 years. This will help reduce our high-risk dependence upon imported oil, with obvious economic and national security benefits.

Nuclear power and coal will provide most of this increased generating capacity through the turn of the century. The other energy technologies will help, are needed, and are important. The breeder reactor, the LMFBR, is the insurance policy that will guarantee reliable domestic supplies of electrical energy for centuries to come.

While the budget for nuclear has not yet been released, we do hope it supports this philosophy in general, and the breeder reactor in particular. Congress, and this committee especially, has been supportive of the program, and for that we are very, very grateful.

The administration decision to move ahead with the liquid metal fast breeder reactor program and its fuel cycle notifies the other industrialized nations of the world that the United States is serious about nuclear energy and the contribution that it can and must make in supplying energy for national growth. The U.S. breeder program should have a goal, a clearly stated goal, and I believe that major goal should be the achievement of successful demonstration of a full-scale liquid metal fast breeder reactor plant and associated fuel cycle technology by the turn of the century. I believe this is a prudent goal, considering that breeders will conserve our domestic uranium resources for centuries. Achievement of this goal, though, will require that we return to a focused mission oriented program.

In 1976 the United States was moving forward on what I would consider to be a strong mission oriented program that involved a logically planned series of breeder test, demonstration and prototype facilities. The fast flux test facility previously mentioned, in Richmond, Wash., is one of these test facilities. It has achieved initial full power operation, and we are currently preparing this test facility to run important natural circulation tests that will confirm inherent safety features of the sodium-cooled breeder.

The 375-megawatt electrical Clinch River plant was to be the next step in this mission oriented program. As we know, starting in 1977 the previous administration began efforts to terminate this project. Although their efforts failed, these efforts have resulted in the project's schedule being delayed almost 5 years and the cost being increased by nearly $700 million.

Our first priority in returning to a focused mission-oriented breeder program must be a strong commitment to build the Clinch

River plant. We join with the administration, and hopefully Congress, in agreement on moving forward with this project.

The Clinch River breeder reactor project was authorized by Congress 9 years ago. Thanks to Congress, the project has continued most of its systems and component design and test programs even though the licensing and construction activities have been on hold for the last 4 years.

More than 80 percent of the Clinch River design is now complete, $1 billion has been invested to date in the project. Over $500 million worth of plant hardware and equipment has been ordered, of which about $313 million has been costed—has been paid for. And as Mr. Iacobellis explained, we already have close to $130 million worth of this hardware completed, delivered, and sitting in place ready for the start of construction.

In achieving this substantial progress, a highly specialized technical team has been developed. If we take a look at what currently exists and if we take a look at the reactor manufacturers, the architect-engineer, the constructor, the Project Management Corporation, and the Department of Energy, we have a team of over 1,500 experienced scientists, engineers, and designers working on the Clinch River plant project. If we include the 2,400 personnel in the next subcontractor tier, we have a total of about 3,900 people working on the project throughout the United States. As Mr. Iacobellis mentioned, this team is a national resource and it is currently dedicated to initiating plant construction and achieving operation in the shortest possible time.

Despite the delays that have been imposed by the previous administration, proceeding with the project is the only practical choice, and this is because it will cost less, can achieve critical project objectives sooner, and will entail less technical risk than any other alternative that has been considered.

With $1 billion already invested and approximately $2 billion required for completion, Clinch River is the most cost-effective approach to demonstrating power producing breeder technology on an electrical utility system. In addition, the plant will provide a flexible test bed for information and experience vital to future plants.

The Clinch River plant is an intermediate-sized facility about one-third the size of present-day commercial generating stations. This size was established by knowledgeable engineers and technicians as the most prudent scale-up of liquid metal fast breeder reactor technology. It represents a necessary step in the evolution of plant equipment; midway between test facilities such as the fast flux test facility and commercial size plants as might be typified by the 1,000-megawatt large developmental plant. This is the size of scale-up that has been successfully demonstrated with light water reactors and also the size of scale-up that is being demonstrated with the foreign breeder programs that Mr. Iacobellis described. I believe this is a prudent size selection.

Over the 4 years of delay imposed by the previous administration, the Clinch River design has been kept current. It has not been stagnant. And I would like to provide only a few examples.

Clinch River has adopted a new reactor core design called a heterogeneous core. In the heterogeneous core, blanket assemblies with fertile uranium surround the core and are also interspersed within the core. This results in better breeding performance and saves millions of dollars in reducing the number of fuel assemblies and control elements that are required. Foreign breeder programs now are expected to adopt this concept in future plants. The heterogeneous core also provides greater flexibility for testing alternate fuel systems in a breeding, power-producing facility.

Project engineers have also specified an improved design for the reactor internal structure that exists right above the core, where the hot sodium exits the core. This approach will significantly extend the lifetime of the breeder reactor system. This is an approach to minimizing thermal stress effects. It is unique and unsurpassed by any other breeder plant now in existence or being designed in the world.

Another instance of design enhancement is the incorporation of what is called multiplexing in the Clinch River plant. Multiplexing is an electronic advancement relatively new to the nuclear industry. It has been around in other areas. It allows thousands of signals to be transmitted simultaneously along a single circuit. Clinch River will extend the nuclear industry state of the art in this advanced electronics technology. Multiplexing very importantly will save more than a million feet of cable in the plant and thus reduce the construction schedule, improve reliability, and substantially decrease plant costs.

As the lead manufacturer on the Clinch River project, I join with all electric utilities, together with other equipment manufacturers and suppliers, in urging the completion of Clinch River at the earliest possible date. Construction could begin next year, provided the required approvals are obtained.

Further delay in this project will result in increased costs in the range of $100 million to $150 million per year of delay. We solicit your continued support so that we may get on with this important task.

I was asked to also discuss the balance of the breeder program. Again, without the benefit of seeing the budget, it is somewhat difficult, but I would like to make just a few general comments.

If we are to achieve the breeder program goal that I referred to earlier, at a reasonable cost, then we are going to have to make maximum use of the physical facilities and the experienced people resources that have resulted from nearly 30 years of breeder development in the United States. We must also make intelligent use of the growing amount of valuable breeder data and experience being developed in foreign breeder programs. Bilateral technology exchange agreements presently exist with many of these industrialized nations. These should be looked at and considered for expansion so that foreign plant operating experience is included, to the degree possible, in our program. Also, as suggested by others this morning, I support this country pursuing the possibility of collaborative partnership arrangements with appropriate foreign nations on large plant design and selective supportive technology programs.

To achieve our major program goal, all of this is going to have to be focused in a logical mission oriented program. In so doing, all test facilities and base technology programs should be evaluated against their ability to contribute to resolving technological, economic, or safety issues that relate to breeder plant design, construction, and operation.

The next major step in the program I believe should be a large developmental plant which incorporates experience and lessons learned from the fast flux text facility and the Clinch River breeder reactor plant. This plant, in the 1,000-megawatt range, will be compatible with the size which will be utilized by the utility industry in the future. Design work on this plant should benefit directly from the uniquely talented design team currently working on the Clinch River project. In fact, I believe that the design work on this new plant should increase at a rate proportional to the design talent leaving the Clinch River project, which will occur over the next couple years. Hence we would make maximum use of this experienced design team and the sunk investment in creating that experience.

All future breeder technology programs should then be supportive of this large developmental plant, and they should also be supportive in a broader sense of achieving the overall programmatic goal, that being successful demonstration of a full-scale breeder plant and associated fuel cycle technology by the turn of the century. As such, there are some items that should be given priority, and these include the following: Safety programs which focus on the reliability of the reactor shutdown and heat removal systems and otherwise support the licensing of safe, reliable future plants.

Component programs with added emphasis on the testing of hardware, especially prototype models of steam generators and sodium pumps. These are the parts of the system that have to be scaled up where there is greatest uncertainty.

Fuels and materials research and development utilizing FFTF and other facilities, but focused on providing the support needed for the large developmental plant.

Fuel fabrication of mixed oxide fuels, with emphasis on remotely operated fully automated technology which reduces personnel exposure and improves throughput and overall economics. And also a fabrication technology with scrap recycle capability to conserve the fuel feed material.

And last, fuel reprocessing and waste treatment technologies that are unique to liquid metal fast breeder reactor fuels.

I believe that existing test facilities should be used to the degree possible to provide extensive testing and demonstration of these advanced concepts.

By proceeding with the development and demonstration of the breeder reactor, the United States, I believe, is making a strong statement to all the world that we will continue to be an important, reliable voice in the world energy community. According to the DOE nonproliferation alternative systems assessment program results, they indicated that the United States will achieve much stronger, effective influence on how foreign countries run their advanced nuclear technology programs only if we show leadership as a breeder reactor developer. The International Nuclear Fuel Cycle Evaluation also endorsed liquid metal fast breeder reactor development and its relationship to the international situation, as Dr. Culler very succinctly pointed out. It is my belief that a strong mission-oriented breeder program will increase this country's ability to influence international safeguards and controls over the worldwide sale and use of advanced nuclear technologies.

A commitment to build the Clinch River breeder reactor plant will be a big step in reestablishing the U.S. nuclear power prestige and credibility on a worldwide basis.

Thank you.

Mr. YOUNG. Thank you, Dr. Yasinsky, for your fine statement. We will proceed now with Mr. Kearney. Mr. Kearney, your prepared statement will be included in the record. Please proceed, sir.

## STATEMENT OF JOHN J. KEARNEY ON BEHALF OF ENERGY AND ENVIRONMENTAL ACTIVITIES, EDISON ELECTRIC INSTITUTE

Mr. KEARNEY. Thank you, Mr. Chairman.

I am John J. Kearney, a senior vice president of the Edison Electric Institute, which is the association of the investor-owned electric utility companies in the United States, and its members provide about 78 percent of the Nation's electricity and serve over 67 million customers.

I am pleased to appear before you today to discuss the electric utility industry's view of the appropriate direction of the Nation's LMFBR program. Our industry reconfirms, after continual evaluation, our firm conviction that breeder reactors must be developed as a long-term fuel resource for the production of electricity, and the LMFBR is the preferred technology. And I specifically appear before you today to support the CRBR as an essential part of the program to accomplish that objective.

While it is evident, I think it would be well to point out that electric utilities are energy converters and therefore we do not have a vested interest in any particular fuel resource or any particular conversion process. Our objective is to provide electricity at the lowest practical cost on a dependable and reliable basis, and in a safe and environmentally acceptable fashion. With this objective in mind, at this stage, the conservative, high confidence path necessary to future electric utility operations requires the early development of the LMFBR technology to have it available when commercialization is needed.

As has been indicated by Dr. Yasinsky, there has been a gradual and continued shift of the energy mix of our Nation toward a larger role for electricity over the next several decades. Our studies reveal that electricity consumption will grow faster than the national economic growth and twice as fast as overall energy consumption. This means that new plants will be needed to serve our growing economy, to displace oil and gas as already has been referred to, and to replace obsolete plants. In achieving this growth, only coal and nuclear are available in significant quantities for new electricity production. And for reliability reasons, we must not allow ourselves to be limited to one fuel source, but instead must proceed with the building of both coal and nuclear powerplants.

Numerous studies have been made over the past two decades to evaluate the many nuclear options and to define the preferred technology. Several of these have been referred to today: The international nuclear fuel cycle evaluation program that was international in scope and performed by 66 nations, the nonproliferation alternative systems assessment program which was performed by the Federal Government, and more recently the National Academy of Science Committee on Nuclear and Alternative Energy Systems. Each of these studies, and those that preceded them, came to the same conclusion: that the LMFBR offers the best long-term technological prospect for insuring an adequate lifetime fuel supply for the nuclear powerplants that will be needed in the next century.

We fully recognize that the LMFBR technology entails major challenges that will require massive efforts in both manpower resources and in developmental funding. Building upon the research and development efforts of the past 25 years we are definitely at the point where a demonstration facility should be built and operated as soon as possible. Other steps will be required to provide the basic knowledge and confidence that is necessary for the electric utility industry to accept the LMFBR as a dependable power system. This program, as has been indicated, will entail several more decades of effort. The time frame, however, does allow the United States to develop an indigenous breeder reactor capability if it is pursued expeditiously. If we continue to delay such an approach, we may be forced in the future to rely on licensing foreign technology and purchase of foreign equipment.

Major research and development programs must be continued to minimize the overall risks associated with the application of breeders. But the fruits of the research of the past 25 years should be applied and evaluated in a specific demonstration facility to identify those areas where weaknesses point out the need for more concentrated research. Indefinite continuation of research efforts is of little value unless there is sharp focus on a particular facility, and we have reached that stage as far as breeder reactor technology is concerned.

Other members of the panel have referred to the background that we have in both research and facilities and the reason why the Clinch River breeder reactor should be built now, why it is the right size to achieve a prudent extrapolation from the FFTF technology on a path of high confidence.

We ought to construct CRBR on an expedited schedule. While we cannot reclaim the years that have been lost because of the diversionary efforts fostered in the previous 4 years, we must move rapidly to assure that more time is not lost. Completion of CRBR is the next and currently most important step in assuring that our Nation has access to the LMFBR on a timely basis. The overall LMFBR program also must include the development of the breeder reactor fuel cycle which includes reprocessing, fuel refabrication, and the development of systems to resist diversion of fissionable material.

In 1972, the utility industry entered into a cooperative agreement with the Federal Government to undertake the design, construction and operation of the CRBR. A funding pledge of $250 million was provided from a combination of about 750 electric utility organizations, including investor-owned, public, and cooperative utilities. This is the largest utility industry commitment ever made to a program. The 1980 annual report of the Project Management Corporation provides both a pictorial and written presentation that includes a brief chronology of the program, the project organization, its significant accomplishments during 1980 and its current status. I understand that the staff has copies of this, and we would be glad to make additional copies available if it would be of help to the subcommittee.

I think the final thing I would like to say is that it is quite obvious that the commitment of the Federal Government is necessary to the achievement of a successful program. And like my colleagues, since there is considerable international interest, cooperative development with foreign governments should be explored so as to minimize the overall costs to all concerned.

My prepared paper has a summary of these comments, but in the interest of time, Mr. Chairman, I will not read them.

Thank you.

Mr. YOUNG. Thank you very much, Mr. Kearney.

I believe that finishes the testimony, so we will go now to the questions.

Mr. Kearney, some have suggested that we can rely on importing foreign breeder reactors if needed and should not spend large sums of money to develop our own technology. Is this approach reasonable? If not, what are the major institutional obstacles to such an approach?

Mr. KEARNEY. Mr. Chairman, I think it is not only unreasonable, but more importantly, I think it is dangerous. We do import equipment for use in this country: turbine generators, switchgear, insulators and things like that. But in every instance we have a domestic manufacturing capability for this equipment.

I think if we were to take a path whereby we would depend solely on foreign technology, we would end up in a position which would be very dangerous to the security of our energy supply in this country. So I think it would be a wrong thing to do, and I know of no one in the electric utility industry which would subscribe to something of that nature.

Mr. YOUNG. Thank you.

Mr. Lujan?

Mr. LUJAN. Thank you, Mr. Chairman.

I have sat through hearings on all kinds of programs. No one ever backs down, it seems to me. Yesterday we had magnetic fusion, well, that is the most important one according to yesterday's testimony and we ought to put probably $150 million more in than we are putting in. Now we are hearing about the breeder technology. Some years ago I sat on the Subcommittee on Atomic Energy and we were then talking about $350 million that the breeder was going to cost. By the time it was authorized it was going to cost $700 million. Today we are talking about $2.4 billion, but possibly $3 billion. And I am reminded of one of my favorite country singers, Kenny Rogers, and his song "The Gambler." You've got to know when to hold and when to fold and when to walk away and when to run. And frankly, it seems like when you are going from, what was it, $1,400 a kilowatt to $7,000, is it time to fold and walk away or run from the project? I don't know. And I guess maybe that is the discussion that is going on downtown also.

On the one hand, you all tell us, well, breeder technology is already to the point where we can generate electricity, we can produce some fuel. If we can do that, why don't we go ahead and do it? It seems like the rest of the world is, already. According to the brochure that we have, there is, what, six, seven, eight—I don't know how many breeders operating around the world. We have to have our own. Why do we have to have our own? National pride, the fact that we have to buy the technology from somewhere else? France builds reactors, sells reactors with a lot of our technology. As a matter of fact, the whole world uses our technology for their nuclear program.

So I have been one of those who has voted all along to keep it alive, and probably will, I will be honest with you, at this point. But frankly, those thoughts run through my mind: Do we move on ahead with some other things and cut our losses, or are we just going to get deeper into this thing.

Mr. KEARNEY. Could I first respond to that.

Mr. LUJAN. You are all anxious to respond.

Mr. KEARNEY. First of all, Mr. Lujan, I don't think you should hold. I think you should keep on the betting.

Mr. LUJAN. Raise.

Mr. KEARNEY. Raise.

Several observations I would like to make and I think my colleagues can fill in with more of the details. First of all, I think you ought to put the cost figure in perspective. We shouldn't be looking at CRBR like we look at other reactors and think about dollars per kilowatt, because that isn't what we are building CRBR for. It is part of an overall program.

The second point, quite obviously, the cost of CRBR today far exceeds what was the original estimate or what the authorization was. Again, I think you have to put that in perspective, and I think my colleagues who are closer to this than I am can. But you have to consider two important things. One is the licensing and refit requirements, and the second thing is basically the 4-year delay that has occurred. And I think when you take those into consideration it looks much better and doesn't look as bleak as you might have suggested.

The third thing I would like to comment on briefly is the question of do we have to own our own technology. I pointed out in my testimony that the electric utility industry has no vested interest in any particular process, in any particular fuel resource, and, I think as these gentlemen know, in any particular manufacturing. So in some sense we have an unbiased point of view. But we also have a public utility responsibility to the Nation to supply electricity, a very valuable asset to this country, a very valuable necessity. And I say that it is not a matter of pride that we want to own our own technology, but rather it is a necessity to make certain that we have that very vital and very critical technology that is necessary for the future self-reliance of this country.

Mr. LUJAN. That doesn't exist in these other breeders across the world?

Mr. KEARNEY. I am not sure I get the import of your question.

Mr. LUJAN. A breeder is operating.

Mr. KEARNEY. A breeder is a breeder.

Mr. **Lujan**. Breeders are operating already.

Mr. **Kearney**. Correct.

Mr. **Lujan**. I guess the question is why our own?

Mr. **Kearney**. OK. Well, breeders are operating already, but aside from Superphenix, which is very close to what you might call a commercial reactor, no one else is, including ourselves. If you are suggesting that we either buy or license foreign technology, I would disagree with you. I think this is such a vital technology that we have to know that ourselves. The electric utility industry is interested in seeing that there is manufacturing capability, there is design and engineering capability in this country to do that. And the only way to really do that is to get hands-on work on the thing, and that is why we think it is essential, and it is not in any way a waste of money.

Mr. **Lujan**. But doesn't France sell Westinghouse reactors, basically?

Mr. **Kearney**. I will let Mr. Yasinsky answer that.

Dr. **Yasinsky**. They do sell Westinghouse designed reactor plants under a licensing arrangement.

Mr. **Lujan**. And doing much better at it than we are in the sales program.

Dr. **Yasinsky**. They have been operating under an environment where nuclear power has been accepted as a significant source of their future energy supply. That has not been the situation in this country over the last several years.

Mr. **Lujan**. They sell more than we can.

Dr. **Yasinsky**. I think a key point is taking a look in this country at when we need the breeder. I think from what I and my colleagues said we would like to have the technology ready and demonstrated by the turn of the century.

Mr. **Lujan**. That is my question. Isn't the technology ready and waiting with Phenix?

Dr. **Yasinsky**. No, not for use today in an economical situation and a reliable situation here in the United States.

Mr. **Lujan**. But why is it more reliable in France than it would be here in the United States?

Dr. **Yasinsky**. What we need in this country is not just a breeder. What I hope we have, and we have the basis to go on to achieve it, is the best breeder for our use here in this country. We have the benefit of their operational experience, and again it is a resource that we had better take advantage of. We have a broader, more comprehensive breeder base technology program than any other country in the world. The program we are developing now from a plant project point of view, Clinch River, and moving on from that, is based upon all that we have learned. Now, why should we throw away that wealth of technology that we have developed and pick up somebody else's design for which we haven't developed the technology? In particular, the fuel system, which is the heart of the breeder. In my opinion, with the capability we have, including the fast flux test facility, the experiments that have been run in experimental breeder reactor II, and what we will learn from Clinch River, when we need a breeder in this country we are going to have a far superior fuel system based on the work that we have already done. So let's not throw it away. Let's continue on and build on what we have so that by the time we need a breeder we have the best possible breeder.

Mr. **LUJAN**. Mr. Culler?

Mr. **CULLER**. Your question is a very valid one, and we recognize that at some point in time if we do not have the manufacturing capability built up in the United States that we most certainly will probably import breeders. The important additional thought, however, is for the utility industry I think there is a very strong feeling that there has to be a domestic industry brought into being both with U.S.-learned technology and that which we can import or exchange overseas. And you have heard each of us say now that as we go to the very large-scale demonstration period we think that there is an intelligence in combining our efforts with other nations for the large scale.

I don't believe that it is necessary for us to go it alone, but I think it would be very foolish, as Jack Kearney has said, to assume that the United States can wait and then buy and build the reliable producing infrastructure to supply the largest potential market for breeders in the world.

We look different to other nations. We look like the biggest market in the world. The French are interested in cooperating because the United States, once it starts, will be the biggest market. As a consequence, as we move slowly toward the large breeder period at a steady pace, we most certainly should provide for ourselves the CRBR which will turn out to be useful for 30 years to put in new pumps, better fuel elements in the power producing, to train the innumerable operators in sodium technology. It doesn't have to stay on the line all the time. It is not that important a production facility. We look in the long term at the time when it is necessary to conceive of 50 or so reactors making major input to the electrical grids of the United States.

Mr. **LUJAN**. Fifty breeders?

Mr. **CULLER**. Sure. Basically, it is almost certain that that will occur at some time. It is the only available resource now certain and the only available technology that we can foresee that will provide us with a very long-term source of energy at reasonable cost. And that is the importance of it. It is urgent that we get on with it, but it is urgent that we not slow down. The CRBR provides the test base that is now available in every other country for their own domestic purposes. We can do exchange agreements, and EPRI and the Government have exchange agreements for radiation in France, Germany, and England. Not quite enough. If we are going to build a broad base for 250 investor owned and 400 public sector utilities to buy electricity, the domestic base must be reliable and strong. And that is Jack's point. The industry needs to have the confidence that there is somebody out there that knows as much about that reactor within a phone call or next door who can come in and provide the assistance and the knowledge to run it. So not only do we need the demonstration of the reactor, but we need to slowly build the knowledgeable supporting infrastructure. And that is the important part.

Mr. **IACOBELLIS**. Your last point first, should the components be built in this country? They could be imported, but I would like to introduce the thought of our country's energy independence. With the requirements that we foresee, there would be an overwhelming load on foreign suppliers to do that. We should have the infrastructure here.

Mr. **Lujan**. We are buying more gas than we are using—we are drilling for more natural gas than we are using.

Mr. **Iacobellis**. Yes, I would like to touch on that in a second. I read an interesting article yesterday where a company on the west coast, Aerojet General, last year received numerous inquiries from potential customers about two particular valves. The inquiries came in from London, they came in from Paris, they came in from South Africa, about how much the two valves would cost and delivery schedules. Well, Aerojet General knew that these two valves were only made by themselves, they were unique, and only one country in the world had need for these valves, and that was Iran. So Aerojet General replied to each of these inquiries that the quoted price for those two valves would be 52 hostages. I think there is a moral of that story in this discussion here; and our being held hostage by the OPEC situation.

With regard to the gas discoveries you mention, they offer only temporal relief. It reminds me, especially here as we look around this room and we see that picture there looking at Earth from outer space that the Earth really is a satellite. We are all here together and we face a dwindling supply of fossil fuels. If we were dependent entirely on our own oil in this country, proven reserves, it would last us about 4 years if we didn't change our ways and we couldn't get imported oil. If we are to go further and think of the rest of the world, proven reserves of oil would only last about 30 years.

Now, the fact that we are finding more, that's fine. But these are fossil fuels that have taken millions of years to put on this Earth. When you think of the situation just suggested, it reminds me of being on a desert and you are out of water and everybody is getting panicky. You have a long way to go. And all of a sudden somebody finds a six pack of water, 2 gallons, let's say, and there is elation, there is jubilation, rejoicing. But you are still on a desert. You may be able to go another 3 miles, another 20 miles.

Now, going back to your first point, I sincerely believe that nuclear power is a godsend to this country, to this Earth. And when you think of the analogy, there are hundreds of years of humanity that must continue. And to expect that we can continue finding more gas or more oil indefinitely, I think, is just being shortsighted. And from that standpoint, we know that nuclear fission is an option we can rely on. We know the breeder makes the conventional nuclear option viable with enough fuel to almost go as far into the future as fusion and the renewables. As far as I am concerned, all options should be pursued viorgously.

When I think of the consequence of this poker game you are talking about, the stakes are very, very steep. In fact, for imported oil last year, $80 billion. In my mind, that is 27 Clinch Rivers. We should get on with the Clinch River. We should increase the budget. And in addition to this one program element, we should approve a total LMFBR program. When I think of what is at stake, I am amazed that we heard these same arguments 3 years ago—to delay the breeder—while oil prices keep going up. To me, this budget should be authorized now. We should go forward immediately. While we were in a holding position the cost went up, and now I hear criticism about the cost. You show me anything that hasn't gone up, and especially if you put it on hold. How would you like to be building a home and have it stay on hold since 1972?

Mr. CULLER. Mr. Lujan, there is one point on the gas. Although additional gas is being found, it is being found deep and it is being found more dispersed. We are reasonably sure that nuclear will compete with gas in the home at some time in the 1990's with heat pumps.

The reason we are so interested in nuclear and its continuity with the breeder is that it promises to provide the cheapest and the most abundant resource for the generation of electricity, 25 percent cheaper than anything else. And we now think the French are certain that their breeder in its next version, the next two that they order, will compete with coal in France. So I don't want you to mistake that gas isn't more expensive than coal and oil isn't more expensive than gas. Utilities are trying to keep the costs down to the very minimum. And that is why the urgency for steadily moving ahead.

Mr. LUJAN. I have some other questions, but I will let some of the other members have a go at it.

Mrs. BOUQUARD. Mr. Volkmer.

Mr. VOLKMER. Thank you very much, Madam Chairman.

After Clinch River is constructed and on line and going and we get ready for a commercial plant, who is going to pay for the construction of the commercial plant?

Mr. CULLER. At the present time, because of problems of rate structures and income, it is not apparent that the full cost or very large portions of the cost could be borne by the consumers of electricity, and there is a reasonable uncertainty as to whether or not this can be made. It may be time now for us to think about the possibility for new forms of budgetary analysis in which the very long-term risks such as the breeder, conceivably fusion and some of the options that are available in the synfuel area need to be financed in a different way. In the long term, the risk almost certainly must be shared between the private sector and the Government.

Mr. VOLKMER. The Government is the taxpayers.

Mr. CULLER. The Government is the taxpayer.

Mr. VOLKMER. That is the general public out there.

Mr. CULLER. The Government from taxpayer funds most certainly will be required to participate as the principal underwriter of these long-term risks.

Mr. VOLKMER. Now you are talking about a commercial breeder reactor.

Mr. CULLER. I am talking about a demonstration reactor, that is the predecessor.

Mr. VOLKMER. No: I am past that.

Mr. CULLER. Once the reactor runs, if there is a 1,000-megawatt reactor running and the demonstration has been made, the utilities will buy commercial reactors with no Government support.

Mr. VOLKMER. You are talking about the year 2000 now.

Mr. CULLER. Yes.

Mr. VOLKMER. So you are saying about that the Government will have to participate not only in CRBR but also in the 1,000 megawatt demonstration unit.

Mr. CULLER. Yes.

Mr. VOLKMER. And you are telling me that even though it is known now that electricity from a breeder reactor will be 25 percent cheaper than gas or oil or anything else, that the private enterprise system we have in this country will not support CRBR without Government support.

Mr. CULLER. Or in 20 years at internal rates of money at 10 percent. There is just no economic base. The utility companies cannot put this kind of thing into their rate base. It goes back to the same problem, the problem of raising long-term risk capital in an internal money market where the cost of money is somewhere around 20 percent.

Mr. VOLKMER. What you are telling me is the private enterprise system just all of a sudden for one reason or another has fallen down.

Mr. CULLER. No; I am not. The private enterprise system works well on short-term risks, but not on long-term risks of 20 to 25 years.

Mr. VOLKMER. Fine. That is what I am saying. On long-term risk the private enterprise system falls flat on its face.

Mr. CULLER. That's right.

Mr. VOLKMER. Let's accept it.

Mr. CULLER. Right. And the other nations we deal with, Japan has a mechanism for underwriting long-term risk, France has a mechanism, England has a mechanism, Germany has a mechanism. And it may be time now that we separate these very long term financially difficult risks and create something a little different than we have now.

Mr. VOLKMER. Thank you for the thought.

I would like to continue real fast, if I may. Components have been constructed right along for CRBR, and they are being stockpiled. What funds were used to make those components?

Mr. IACOBELLIS. The ones we referred to in the testimony were Clinch River project funds.

Mr. VOLKMER. What are the sources of those funds?

Dr. YASINSKY. Of the $1 billion, approximately, that has been spent so far, I believe approximately $880 million of that has been Government money through the Department of Energy, approximately $108 million from the supporting utilities, and the remainder from other sources, including the reactor manufacturers.

Mr. VOLKMER. Now, as I read your report, I get a little disturbed that there has been no contribution, since 1977 by utilities. Is that correct?

Mr. KEARNEY. Individual utilities have entered into contracts with what is called a Breeder Reactor Corp. for the collection of funds.

Mr. VOLKMER. That's correct.

Mr. KEARNEY. Breeder Reactor Corp. in turn makes those funds available to the Project Management Corp.

Mr. VOLKMER. Right.

Mr. **Kearney**. In the last 4 years the project has been more or less on hold, and we, the electric utilities, did not know what was going to happen to the project. As a consequence of that, although the contracts are still in force, there have been no payments, but the obligation is still there, and as soon as the project gets back on track I am sure that those funds will be available as the contractual share that the industry entered into with the Federal Government.

Mr. **Volkmer**. What I am trying to get at is this. There have been no contributions as such; they have deferred contributions, just like the Project Management Corp., as I read this, has deferred their contribution also.

Mr. **Kearney**. For good and sufficient reason.

Mr. **Volkmer**. I am not worried about that.

Mr. **Kearney**. You can appreciate that we are, though.

Mr. **Volkmer**. The money that the utilities were to contribute, those moneys are supposedly still in the hands of utilities. Is that correct?

Mr. **Kearney**. Yes.

Mr. **Volkmer**. But it may not be there; is that correct?

Mr. **Kearney**. Well, no, I wouldn't say it may not be there.

Mr. **Volkmer**. Did they put this money aside that they were going to contribute?

Mr. **Kearney**. It depends upon the rate relationship that each utility has with its public utility commission. In some instances it may be in escrow; in others there may be other accounting means that is provided for this obligation. I could not tell you in each individual case what is being done. I do know in a lot of instances it is in escrow.

Dr. **Yasinsky**. If I can just briefly add to that, this money has been put into escrow.

Mr. **Volkmer**. All right. So the money would be available. We don't have to worry about utilities that are right now in financially strapped positions being able to come up with contributions; is that correct?

Mr. **Kearney**. That's correct.

Mr. **Volkmer**. OK. I just wanted to cover that.

Mr. **Lujan**. Would the Gentleman yield? Is that money going to be based on 1977 dollars? The contribution?

Mr. **Kearney**. There is a contractual arrangement for a certain amount of funds, and that is what it will be.

Mr. **Volkmer**. All right. The last thing I would like to cover relates to what I heard the other evening from someone in a private utility. I also heard it here this morning. I am sorry, but I am going to have to disagree with the idea that if we go ahead with the breeder and the nuclear field all the way, that we are going to replace the $90 billion we currently spend on foreign oil.

Mr. **Culler**. No.

Mr. **Volkmer**. I don't agree with that. I know better than that.

Mr. **Kearney**. No; I don't think anybody has said that or tried to infer it.

Mr. **Culler**. Not at all.

Mr. **Iacobellis**. Maybe I should address that.

**Mr. Volkmer.** Yes, because you are the one that said something to that effect.

**Mr. Iacobellis.** Yes.

**Mr. Volkmer.** And I don't like those kind of words, because I know and everybody else knows it isn't true, but I see it on TV, Mobil Corp. advertising we have got to replace foreign oil, let's get on with nuclear. Baloney.

**Mr. Iacobellis.** I am sorry Mr. Wolpe had to leave with his question, he spoke of 10-percent oil being used for electricity. That is close. The number is 14 or 15 percent. With gas, as John pointed out, these fuels contribute 30 percent. And then if you add coal, another fossil fuel, another finite item which will run out some day, it gets up to 75, 80 percent. Now, my point is that nuclear generated electricity should be used wherever possible to offset the use of fossil fuels because we can't use nuclear power in some applications.

There will be more and more use of electricity as the years go on.

Quite often I run across people who say, well, why don't we go to an electric car. They don't realize it has to be plugged into some power source and there has to be some power generator to supply that power. So as we move forward with new technology there are going to be more and more ways of converting our energy use to an electrical form, and then we can use nuclear to supply that power. And I believe that the fossil fuels, finite as they are, should be preserved and used in applications where their flexibility is required, used in those places where we can't use electrical energy and nuclear generation.

**Mr. Volkmer.** I won't deny, Madam Chairman, that we should replace oil, where we can. Natural gas later on. I won't argue that. And I agree with Mr. Culler that the budget cuts for synfuels are disturbing. But I understand, too, that if we import breeder technology then by about the year 2000 or 2025 we will not have the nuclear manufacturing capability of making the vessels, the valves, and everything else. We won't have the manufacturing capability, is that correct?

**Mr. Iacobellis.** That is correct.

**Mr. Volkmer.** The piping and everything else.

**Mr. Iacobellis.** That is correct.

**Mr. Volkmer.** And that is what you are building on.

**Mr. Iacobellis.** Correct.

**Mr. Volkmer.** So we have to make that choice.

**Dr. Yasinsky.** You brought up the question of cost again, and I'd like to add a few more pieces of information here. We mentioned that about $1 billion has been invested in the project so far. We mentioned that the project has been delayed. But if you look back you see that in 1975 the project was rebaselined. And if we take a look at our current estimate right now and say what has really happened during this period, what has been caused by the delay, if we strip out the assumed escalation, which for the project is now over $1.2 billion we see that the real increase of the project for all the other reasons is only about 25 percent. If we take a look at what has happened to the assumed escalation which is now a major part of the project cost, it has increased by 100 percent. So again, it has been delays that have caused the major problems with the cost.

Commenting briefly on two of your points, I also commented on the potential for electrical substitution. I did not mean to be interpreted that that was going to totally wipe out our problem, but it can and in fact will help. In fact, if we do nothing right now, if we just sit here, electrical substitution is going to continue. It has been happening for 30 years. The percentage of electricity to the amount of total energy has increased and will be increasing from about the present 30-percent level to about 45 percent by around the turn of the century, and the additional ways in which we are going to see these benefits are happening at the end-use location, the homes, the commercial facilities, the factories. Many of us live in areas where you can't get oil or natural gas for a new home; it has to be electricity. Others are selecting electricity as a conscious choice. More will be making it an economic choice in the future as the price of oil, and then probably natural gas if it is decontrolled, increase much faster than the cost of electricity.

Mr. **Volkmer**. No question that it is going to go up. It will.

Dr. **Yasinsky**. This is what is going to happen given all the other things occurring right now and given that additional electricity will be needed, certainly nuclear power is one of the prime candidates to supply that.

Mr. **Culler**. I have one other comment.

Mr. **Volkmer**. Could I have one more quick question?

Mrs. **Bouquard**. One quick question.

Mr. **Volkmer**. We have other members. I don't have any more to ask. One quick question for somebody.

If we get on with it, when will Clinch River be completed? Somebody?

Dr. **Yasinsky**. The schedule for Clinch River is that once we initiate site work, once we start site work, we are looking at about slightly less than 7 years, I think 6 years and 10 months from the start of site work. When we will start site work I can't say; that is yet to be determined. But the schedule is totally laid out in all detail as to what has to be done from preliminary site work through completion of construction and plant startup.

Mr. **Volkmer**. That is enough. Thank you.

Mrs. **Bouquard**. Thank you very much, Mr. Volkmer.

Mr. Goldwater.

Mr. **Goldwater**. Thank you, Madam Chairman.

I note that prior to the selection of contractors for the Clinch River project the estimated cost for completion was $699 million. This has been revised upward over the years, obviously. What is the estimated project cost now when completed?

Dr. **Yasinsky**. The estimated project cost right now is approximately $3 billion. And I say approximately because we cannot definitize this estimate until we are in a position where we understand when we will be allowed to start construction. Certainly the sooner we can start the cheaper the price tag will be, because for every year delay it is going to cost at least an additional $100 million.

Mr. **Goldwater**. As far as the design is concerned and the component parts that have been built, is there any reason why we would want to update or modify any of what has already been done.

Dr. YASINSKY. In the comments I did provide earlier, and in my written testimony, I have identified those areas where we have made significant improvements in the overall design, and we have had a continuing effort studying where improvements can be made without jeopardizing overall project objectives.

Mr. GOLDWATER. In your opinion, is the site of the Clinch River, the proposed site, still the right site? Are there reasons to look elsewhere?

Dr. YASINSKY. From our point of view, we see no reason to consider any other sites. The Clinch River site is ideal for this application and all of the work that has been done and is being done right now is aimed toward getting on with construction at that site.

Mr. GOLDWATER. What about the licensing of this facility? Is the Nuclear Regulatory Commission in a position, do you feel, to support this consistent with an optimum construction schedule?

Dr. YASINSKY. I can't personally comment on what their ability will be to support this. Certainly we are interested in getting the construction started and the plant operating as soon as possible to get the information we need and to minimize the cost.

Mr. CULLER. It is likely the Nuclear Regulatory Commission will have to reassemble the team to license fast breeder reactors, and it will take some time, and to do it expeditiously may require some pressure from external sources.

Mr. GOLDWATER. Sam, in looking at your testimony, one of the justifications which you cite, which I think is interesting and I wonder if you can elaborate on it, is that the tailings that we have in place today, if utilized in a breeder system, would provide the equivalent of twice the amount of recoverable coal or 2,400 billion barrels of oil. If it is actually true, it has got to be a very compelling reason to go ahead.

Mr. IACOBELLIS. Yes, certainly. Using the breeder, this fertile but non-fissionable material can be used.

Mr. GOLDWATER. This is the uranium?

Mr. IACOBELLIS. Yes, the tailings.

Mr. GOLDWATER. Uranium-238.

Mr. IACOBELLIS. Yes. Just to give you a bottom line in a sentence. I believe the booklet you have showing that every industrialized nation in the world recognizes this energy source should mean something to us.

Furthermore, it is my opinion that a commitment in this country to the nuclear option, the nuclear conventional reactors and the breeder, will put a tremendous pressure on the OPEC countries and will limit the price increases that we are being held up for on imported oil.

I have attended international meetings where arguments have been made by Third World country representatives that they lean on the United States, the industrialized leader, to bring along the new technology. They point out that as we would go forward with the breeder along with the other bright technology countries, we would be making the conventional nuclear reactors with adequate fuel supplies available to the developing countries. The Third

World is looking to us as the ones to develop the new things like the breeder and the nuclear option so that the dwindling amount of high cost kerosene and oil could be available for some of the lesser developed Third World countries.

When you consider that oil costs $30 a barrel and will cost $50 a barrel, and in fact there are estimates that within 2 years it will be up to $100 a barrel, you realize that the vast energy resource of uranium tailings is just something that should not be left there idle. Furthermore, I believe that just starting to use it will help the supply/demand and the seller/buyer relationships with the remaining oil that the world will need in the interim as we move our primary dependance to something other than fossil fuels.

Mr. **Goldwater**. In this process of breeding, one of the concerns that is raised is the production of plutonium. Is that still a legitimate concern? And if so, how do you answer concerns that are raised?

Mr. **Iacobellis**. Well, as Dr. Culler pointed out in his paper, all reactors produce plutonium. It is not to be looked at as a commodity that we have to worry about disposing of. Rather, it is a fuel and it should be utilized.

Floyd, would you like to comment?

Mr. **Culler**. I think I endorse that, of course. There is an interesting little chart at the back end of my paper that shows that fundamentally more plutonium is produced by the Candu type reactors per unit kilowatt-hour than the light water reactors. The breeder reactors have a large inventory of plutonium and are essentially plutonium banks. The place to put plutonium and have it safely handled, is to make it radioactive as all get out in a reactor producing power and more plutonium, rather than letting it sit around in storage barns.

As a consequence, this idea that was expressed in the INFCE report, this big international study, the idea that the industrial nations with breeders will serve to draw from the developing nations the plutonium stock for breeders, with a reciprocal supply as long as the enriched uranium lasts, for 50 or 60 or 70 years of enriched uranium, which is of course basically in its enriched form not a weapons material. So the idea that the ultimate nonequilibrium but almost equilibrium of having plutonium in breeders as an adjunct to the control of plutonium in commerce is a reasonable one.

So basically, the problem of plutonium is not unique to the breeders. It is a problem for every reactor consideration.

Mr. **Goldwater**. In other words, the reactors that are producing right now, that are on line right now are producing plutonium.

Mr. **Culler**. And if you look at it, the LWR per kilowatt-hour produces a little bit more plutonium per kilowatt-hour than the breeder will, because the breeder burns plutonium. It produces an excess, however.

Mr. **Goldwater**. But that is not a new problem or unique.

Mr. **Culler**. It is surely not unique.

Mr. **Goldwater**. I have one last question concerning your cost of a kilowatt-hour. I notice that the French Superphenix in your chart is going to be producing electricity at about 5 to 6 cents per kilowatt-hour, which is about three times the cost of electricity I guess in this country from regular nuclear reactors.

Mr. CULLER. If I may, Dr. Starr and I had breakfast with the chairman of the French program this morning, and we reviewed the current views on costs, and that number is about correct. The French anticipate the cost of electricity from their first breeder to be about twice what it is from the LWR and twice, maybe a little bit less than twice that which they could generate from coal. However, they do anticipate being able to reduce the capital cost on two breeders that they will be ordering almost—maybe four—sometime by 1984 or 1985, to about 15 percent above the cost of LWR-generated electricity at that time. They find that the breeder cost at that level will be less than the cost of generating electricity in France from coal.

Now, I made that point in my paper earlier, that not only should you compare the cost of breeder-developed electricity from LWR's, but with the next competitor in the market, which is coal. And I think most of us are reasonably confident that we can produce electricity from breeder, not just LWR, at costs competitive with or less than the cost of electricity derived from coal with all of the so-called required environmental protection. And the French this morning basically said that is what their program is based on. They will be ordering four large breeders to be sited in a central station in anticipation of achieving these costs before 1990.

Mr. GOLDWATER. Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much, Mr. Goldwater.

I would like to recognize the ranking Republican member of the full Committee on Science and Technology, the Honorable Larry Winn of Kansas. I think that we all owe him a great deal of gratitude because he has never waivered in his support of our breeder program, our nuclear program. He has certainly used his influence to see that our program goes forward, which we very much appreciate.

Mr. WINN. Thank you, Madam Chairman.

I don't have any questions, but I noticed that some of the gentlemen wanted to respond to Mr. Volkmer's questions and were cutoff, so I will just say if you care to put that in the record in response to my putting it in the record, I urge you to do so.

Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you, Mr. Winn.

Mr. Lowery.

Mr. LOWERY. Thank you, Madam Chairman.

Being the new kid on the block, there is much to digest. This is not a simple subject, so please bear with me.

The impediment to breeders, is to bring them on to full-scale production, is it a technology problem at this point, or is it a governmental problem in terms of the regulation, the delays due to funding? Where are we?

Mr. CULLER. For the moment it is a problem of national policy on the part of the Government. I mean the uncertainty of the breeder program. There are many uncertainties, but the controlling one now is actions on the part of the Government. If the Government changes, supports reprocessing and decides that a breeder program is in the national interest, there will be other problems that emerge and are part of the picture, but the controlling one now is the endorsement and certainly of Government support.

Mr. Lowery. It is not technological?

Mr. Culler. The breeder can proceed through the normal protracted stages of development. As one moves an industry toward commercial scale, you are met with technical problems, most of which we think are soluble, they are problems of engineering scale-up, of increasing the size of equipment from, oh, one-third to four times as big. So it is the normal industrial scale-up that we are looking at now, rather than fundamental issues.

Mr. Lowery. The technology is there, but it is just the engineering at this point?

Mr. Culler. The basic technology is there, but the engineering evolution has yet to occur, and the acceptance and the safety and licensing.

Mr. Lowery. Do you see the cost of breeders competing with the traditional light water approach? Even with the cost of fuel, traditional fossil fuels, albeit we are running out of them, is the breeder cost competitive?

Mr. Culler. At the time that breeders are available at a steady pace for commercial introduction in the year 2000 or so, we are reasonably confident that the breeders will compete with LWR's and surely all of their fossil contenders. The Russians are going directly to the breeder. They are not going to fool around much with the LWR's because they don't want to make that investment. They will build light water reactors in the satellites.

The French are going more or less directly toward breeders because they think that by the time they have them developed they will be competitive.

Mr. Lowery. What are the specific obstacles to completion? And I am not talking about just Clinch River, but looking beyond that in terms of full-scale commercial demonstration. At this point how would you have to classify Clinch River? Is it a demonstration facility? Is it a test facility? Is it a prototype? Is it all of the above? I know there were a couple of previous questions on this.

Mr. Culler. First of all, I won't alone comment on what the obstacles are, but we all recognize that the Clinch River demonstration or test reactor is just that, and it is not enough because it is one-third the economic size and the scale-up to large size must occur. We look upon it as the U.S. test bed and the first demonstration in the United States of the generation of reasonable quantities of heat from big gear with a sodium-cooled reactor and breeder and we will get a lot of information and experience on it. It will serve over a period of 30 years as a reliable test bed for the introduction of the improved heat exchangers, pumps, better fuel, and training for people who are strangers to sodium technology. So in a sense it is part prototype, part demonstration at intermediate scale, and surely a test and an evaluation reactor for a period of 30 years.

Now, others on this?

Dr. Yasinsky. When we consider what it is going to be used for, we see that CRBRP will be both a demonstration plant, and a test facility.

I think I have a very simple, short answer to what are the obstacles with getting on with the program. I think that the major obstacle is confidence and belief that the Government support necessary to achieve our objectives and goals is really there. The delay over the last 4 years has severely crippled that confidence to the point where those in the private sector who do believe in this technology are going to be a little reluctant when it gets around to how we decide to proceed. I think the best thing that can be done to start to renew that confidence is a strong commitment to build Clinch River and getting on with starting the construction in the fastest way possible.

Mr. IACOBELLIS. Just another comment in that direction. An obstacle to a program like this, any program that is of this nature, is that we are dealing with a large number of years. We have background that goes back two or three decades. Looking forward, if we move out now, the commercial readiness of this device is at the turn of the century. This is the type of program that requires continuity for specialists and the infrastructure. I tried to emphasize this point earlier in my prepared statement, and it was also mentioned earlier by my colleagues here, that every one of the other countries has continuity in their programs, the French have moved timely from the 250-megawatt Phenix to the 1,200 megawatt Superphenix I. They are already well along in the design of the Superphenix II; they have selected the size, 1,500 megawatts.

The Russians have done the same thing, the 350 megawatt, the 600 megawatt, and we understand they have settled in on 1,600 megawatts for commercial replication.

This is what our program needs: continuity; and the private sector cannot be expected to provide that, just because of the development time involved.

Furthermore, they couldn't provide it if there is going to be vacillation on the part of the administration between one 4 years and the next 4 years. And if you look around, you see that vacillation is one of the things that, for any institution, makes it very difficult for any program of this depth and nature to maintain continuity.

Mr. CULLER. I want to add too the certainty of long-term financing, the continuity of funding presents both the public sector, the Congress and the private, the utilities and the supporters, with a problem insoluble at present where risks must be spread over a period of 25 years or so. And we identified it earlier just before you came in as something that really has to be thought of for nuclear in particular, but not that alone. This whole problem of underwriting long-term risk.

So financing that does not necessarily require an annual debate in Congress for continuity may be something we would like to think about. And I say "may" because it is a new thought.

The other area that we have not mentioned this morning of course is the licenseability and generally the public acceptance. And we must not minimize that. First of all, as far as the regulations and the licensing, much work must be done by the NRC, very much work. The whole question of fast reactors was left in 1977 and the group of people familiar with the technology dispersed, so there is no ready and waiting organization to pick up the very necessary and vital regulatory and licensing answers.

In addition to that, the attitudes broadly on nuclear power in general, on broad questions of waste disposal, as well as the particular breeder must also be addressed.

The question of public confidence I think can be partially buttressed by having a statement of firm intent, of firm endorsement on the part of the Congress and the administration in such actions. And that is part of the confidence that John Yasinsky mentioned, the building up of confidence that we will proceed intelligently and not rashly toward something which has merit.

Mr. LOWERY. How much are we talking about in this year and each subsequent year, then, for that to happen from the public standpoint?

Mr. CULLER. None of us have seen what the current budget proposals are. And I think it might be best if we leave that to the Department of Energy for exposition. I am just not in a good position, and I am sure most of us are awkwardly placed to comment on that today. We will be seeing the budget markups and such very soon.

Mr. LOWERY. Is there an ideal figure to bring it on line? Certainly dollars will be somewhat controlling.

Mr. CULLER. Well, over a period of time the breeder program of course will amount to many billions of dollars. The CRBR first, the design and construction of a larger prototype to be available for operation after 1990 or 1995, and a demonstration recycle facility will bring the total cost to many billions of dollars. It is probably no less than five.

Mr. LOWERY. You are talking these big numbers. I am one who comes from the eighth largest city in the country, San Diego. The budget last year was $290 million that is with an "M" on it—million dollars—to run a city of that size, and we talk in terms of a couple of billion. You know, pretty soon it adds up to a whole lot of money.

Well, are the figures that refined, that well developed for this program?

Mr. CULLER. The program itself has not been defined broadly as to what will be accomplished. And until that is done, I think we are all whistling a bit. And during the early part of this year we hope that between the administration and your committee and other parts of Congress that a program definition as well as estimates can be worked out. We are in a position to do so, but we are not sure that it is acceptable to anybody except us.

Mr. LOWERY. Madam Chairman, just two more questions.

What are the immediate environmental concerns? Are there any?

Mr. CULLER. The environmental concerns are no greater than those for existing reactors. And as I commented in my testimony, a substantial case can be made that the fast reactors are safer. They do not release iodine that readily. They do not have as much stored energy. The British have cut off the circulating pumps in their breeder with the reactor shutdown and taken the after-heat out by natural convection alone. So that the controllability, the questions of safety appear to offer us an easier system to operate, and overall potentially a safer system. And there are no new environmental questions involved.

Mr. LOWERY. The last question. How would you as experts in the area of breeder technology contrast it to the HTGR approach in terms of cost, energy efficiency, fuel potential?

Mr. CULLER. The HTGR cannot breed. The best that the HTGR can do would be to increase by maybe 20 to 30 percent the conversion of U-235 to U-233, not plutonium. In the long run the HTGR's would provide a very short window in time as an adjunct fuel extender. The HTGR is an important reactor concept for not necessarily primary power at present, but for the possibility of developing high temperature heat. It is not a primary contender, as the INFCE studies and studies all over have shown, to provide increases of fuel supply.

As far as cost goes, neither HTGR nor the breeder has been built on a big enough scale to be accurate about the relative cost between the two. They are likely to be close to each other in cost.

Mr. LOWERY. And the timetable?

Mr. CULLER. The development timetable for any reactor that we take on now going to big scale is 15 to 20 years at the pace at which we can build. Any new reactor.

Mr. LOWERY. Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much.

First of all, I would like to apologize for having to leave and really missing the heart of your testimony. But we have a little issue called a hearing before the House Administration Committee to provide for the continuity of this committee. I am sure that you all can understand that.

I would like to touch on something that Congressman Goldwater got into when you were talking about the plutonium issue and also the issue of confidence. I am trying to combine the two to really get a summary of the safety advantages of a breeder reactor compared to a light water reactor. I think this is valuable in our testimony.

Mr. CULLER. Madam Chairman, there are little technical things, but basically I think the most important safety advantage is the ability of sodium to move heat much better than water does, and sodium does it at atmospheric pressure. The water reactors, of course, operate at relatively high pressure, around 2,000 pounds per square inch. And at the time the water reactor is shut down, either routinely or under an incident, excursion or whatever, all of the stored heat at high pressure steam conditions must gradually be taken from the system and the after-heat due to fission products must be continually removed. The water systems have been engineered so that they do take out the heat, and there are two and in some cases three or four backup systems to remove heat from the core under all conditions. With the sodium system, however, it is possible to allow natural convection, without any pumps, without any motive force, to allow the motive force of heat alone moving sodium from the hot spot to the cold spot to take after-heat and the energy after shutdown out of the system faster than in the water systems. As a consequence, this is the primary safety advantage.

It looks as though from the French experience and the operating experience in Russia and England that the sodium coolant is very benign. The French this morning said that they have only had two leakers in the Phenix reactor, two leaking fuel pins in the years that they have operated. Water is a more aggressive corroding agent than sodium, and sodium leaves the reactor in relatively decent condition.

There are neutronic reasons and such for considering the fast reactor equivalent to or possibly a little bit safer, a little bit too technical, I guess. But the neutronics are relatively equivalent or a little safer than the water-cooled reactors. All in all, the system will probably offer safety and reliability advantages from the experience collected in Europe that lead to overall easier and therefore safer operation.

It may be easier to operate the sodium reactor than a water reactor, and that was what was said at breakfast this morning with the man who is in charge of the French program: "We just find our operators are more relaxed in the operation of these reactors. So we are beginning to learn a little bit of the subtleties."

Dr. **YASINSKY**. Madam Chairman, I would just like to add briefly to one point that Dr. Culler made, and that is the capability for these reactor plants to sustain coolant flow through natural circulation. It was mentioned that tests have been performed in the European reactors on this. I think it is important to note that in our FFTF reactor in the State of Washington, that the end of last year we completed tests up to 35 percent power where we shut the reactor down, turned off all electricity and let the natural circulation capability cool the core. What we found was that the data we obtained in FFTF clearly showed that the plant's natural circulation core-cooling capability is more than adequate—FFTF is the most highly instrumented plant ever built, and the data we obtained indicated the performance was better than the analysis had indicated. We are right at this time preparing to go back up to power. We will run tests from 75 and 100 percent power, and we are confident again that we are going to demonstrate once and for all that for this design of a reactor, that the natural circulation coolant capability is an inherent safety property.

Mr. **CULLER**. In conventional water-cooled reactors, the fuel is clad in zircalloy which under accident conditions can react with the water to form hydrogen gas. If you remember, that is what happened at Three Mile Island. The probability of having such a reaction with the fuel in a breeder which is clad in stainless steel, and less susceptible to oxidizing is, therefore, considerably reduced.

Mrs. **BOUQUARD**. Let's just touch briefly now on this question of obsolescence. Do we really have assurance that our breeder reactor program is going to be competitive in 20 or 30 years?

Mr. **CULLER**. Not ironclad. But the best estimates that the people who do these kind of estimates can make, would indicate that it will be. The breeders will be able to produce power within competitive range for the generation of electricity. Now, that is as good as we can do. We don't have experience enough. The French are pretty confident, the Russians are pretty confident. They are further ahead than we.

Mrs. **BOUQUARD**. Do you think that our design team in this 4-year interim has made progress in advancing the technology?

Mr. **CULLER**. Yes.

Mrs. **BOUQUARD**. That we will apply what we would not have had 4 years ago? That is really what I was getting at.

Mr. **CULLER**. Yes, indeed.

Mrs. Bouquard. Even though we have had a slippage.

Mr. Culler. Yes.

Mrs. Bouquard. We are behind France, Germany, and Great Britain.

Mr. Culler. Yes.

Mrs. Bouquard. But we have used this time for working out our design.

Mr. Culler. Yes; I think our design on the reactor that is now conceptually put together has advanced the art. And so have all the people who participate in it.

Mrs. Bouquard. On international participation—what do you really think are the advantages or the difficulties of entering into such agreements?

Mr. Culler. Well, the first and obvious advantage is that we share the costs. Second, I think it provides stability to each nation's participation. If we are committed jointly with other nations, it is more likely that we will not vacillate as widely. And similarly, they think so, too. The Japanese would like to see that because it stabilizes their program further.

Last of all, I think there is a very high probability that two or three major groups in the world developing breeders using the resources of people as efficiently as they can will produce a better product. I think cooperation with other nations, with the skills that they bring to it, will add to our own knowledge and balance off biases that naturally occur in every semiclosed community. I think that the interactions will be important. There are disadvantages.

Mrs. Bouquard. That is what I wanted to hear too.

Mr. Culler. Well, it is always slower. It is always slower to reach agreements on who is going to do what and to resolve the technical issues, the very real technical design or operating issues that occur. It also makes a little bit more uncertain when everything is successful as to who will be the major purveyor of the finally developed art. And in talking with the Germans and the French about how they arrived at joint agreements and all of the joint agreements that occurred, those of us who work on the technology agree very soon, but those who discuss the handling of the commercial prerogatives have great difficulty in agreeing. So basically there are problems to be solved and there are disadvantages in all kinds of international things because they move slowly, possibly more slowly than a single commitment. I think the advantage internationally of perhaps stabilizing our own intent a little would offset the slowness that we would pick up by international agreement.

I am sure other people have ideas in addition to mine. Jack?

Mr. Kearney. I really can't add much to what Floyd has said. I think the utility industry would look favorably upon some type of an international cooperation program because of the cost involved. I think Floyd has indicated both the advantages and potential disadvantages. But I think that the advantages would be inclined to outweigh the disadvantages.

Mrs. Bouquard. Could we decide on certain areas where we would embark on a cooperative venture that would not slow down the process?

Mr. **Culler**. We could, but I think if we really do it this time we ought to go whole hog. If we don't go whole hog, then we should explore areas of exchange. But basically, the thought now being evolved is that by sharing the huge risk and sharing the technical knowledge very openly during the demonstration period, we will all advance a little bit more rapidly. And as we ought to agree that one reactor gets put one place and then the next one someplace else. It may be a common reprocessing and fuel-cycle center.

Mrs. **Bouquard**. I know you are all a little bit weary, but one last question. If we decide to go ahead with a large demonstration reactor of a pool design, would this impact the decision to construct the Clinch River breeder reactor?

Mr. **Culler**. My answer to that is "No." I think that the loop system for the Clinch River breeder demonstration is an advantage because it allows us to use that system more effectively for future experimental development of gear. And I am sure that others have comment.

Mrs. **Bouquard**. I would like to hear the reasons.

Dr. **Yasinsky**. I think I agree with what Dr. Culler indicated there. If you take a look at a pool-type reactor and a loop-type reactor, in a loop-type reactor you have the vessel and you have two sodium loops and then you have your steam cycle on it which produces the steam for the electricity. The secondary sodium loop along with all its pumps, auxiliary systems and the steam cycle, which is a major part of the plant, is basically the same for either concept. The difference is that in the pool concept, what is basically in the primary loop in the loop concept is inside the vessel, so you have a much larger vessel. So you have differences from that point of view. The core itself, the fuel, the materials that go in provide much more commonality. So I think there is an awful lot that is common between the two.

Also I think that independent of what the next plant is, we have proceeded on Clinch River to the point where we have a definite design. If any one were to suggest changing that design at this time it would be foolhardy. We must get on and complete CRBRP. What we build in the future should be based on what we feel is the best next step. That next step in itself will not commit this country to building only pools or only loops. The verdict is not out and even those countries in Europe who are developing the pool will admit that the future will probably see a mixture of pool and loop reactors, just as in the light-water reactor area we initially started out with pressurized versions and boiling versions and we have gone on and they have both experienced success. It is premature at this point, based on what we know today and the lack of full-scale operation for extended periods of time, to say that one is better than the other. They both appear to be good concepts. Both will work.

Mrs. **Bouquard**. Actually the main differences that we are talking about relate to the design work on the reactor vessel. Is that correct?

Dr. **Yasinsky**. The major difference would be the reactor vessel and what is inside it. The pool has a much bigger vessel and the primary circuit that is normally coming out of the vessel for the loop is, in effect, inside the vessel. There is an awful lot of commonality between the loop and the pool, so there are significant benefits from Clinch River independent of what we build in the future.

Mrs. **Bouquard**. So in your estimation, this is really of no consequence.

Dr. **Yasinsky**. Any attempt to use the pool/loop argument to hold up progress on Clinch River is totally irrelevant. The challenge is to get on and build this plant. The question of pool/loop remains as to what we do next. And again, independent of what we build after Clinch River, in my opinion we are going to see a future where both pool and loop plants will be successful.

Mrs. **Bouquard**. Thank you.

Mr. **Culler**. Sam has a comment about this. He has a little study that was done I didn't know about.

Mr. **Iacobellis**. I anticipated your question, perhaps.

Mrs. **Bouquard**. Thank you.

Mr. **Iacobellis**. The subject of pool-type plants versus loop. This subject has been studied often during the last decade. Findings always show that one concept may have a narrow advantage or advantages in one area while the other concept has advantages in other areas. About 80 percent of the plant features are the same for both concepts, and we really won't know which, if either, concept has a real net advantage until we have constructed and operated both types. I think this supports the previous comments from Dr. Yasinsky and from Dr. Culler. And I am of the strong conviction that the Clinch River with its 80 percent commonality should go forward in its present configuration; we will gain much from it. And as previous speakers have pointed out, it does offer some flexibility in using it with alternate component testing as we look to the future.

Mrs. **Bouquard**. Thank you very much.

I appreciate your expertise, and your willingness to give of your time so freely today. I know you spent a great deal of time in preparation for your testimony. So our thanks are entirely inadequate, but we do appreciate it. We could have gone on and on, but for today, thank you very much, gentlemen.

Our next witness is Dr. Thomas Cochran of the Natural Resources Defense Council. Tom, we welcome you to our subcommittee today.

## STATEMENT OF THOMAS COCHRAN ON BEHALF OF NATURAL RESOURCES DEFENSE COUNCIL

Dr. **Cochran**. Madam Chairman, I want to thank you for the opportunity——

Mrs. **Bouquard**. Just 1 minute.

The subcommittee will be in order.

Please proceed with your testimony, Dr. Cochran.

Dr. **Cochran**. Madam Chairman, I want to thank you for the opportunity to testify before this committee on this issue that has been of longtime interest to both of us, although we have very different views on that issue.

Mrs. **Bouquard**. Dr. Cochran, as I told our previous witnesses, we have your testimony that will be made a part of the record. If you choose to summarize, you may do so.

Dr. COCHRAN. Thank you. I will not read the entire testimony. In fact, before I get to the testimony I would like to respond to one or two of the issues that were raised by speakers that preceded me.

First, I want to call your attention to the fact that the speakers did not agree on the mission of the Clinch River reactor. Dr. Culler wants it as a research and test facility, whereas the other two speakers regard it—two of the other speakers, Dr. Iacobellis and Mr. Kearney, still refer to it as a demonstration plant.

With regard to the discussion on page 3 of Dr. Iacobellis' testimony regarding the uranium tailings and his subsequent statements on the need to mine the tailings, I would point out that those tailings will be there in any case. We are fortunate to have those tailings because they are a proven reserve. It doesn't, however, make any more sense to mine those tailings before it is economical to do so than it does to hook up solar generators to batteries and take advantage of the free energy of the Sun, also an inexhaustible resource, before it is economical to do so. We could go out today and capture all the sunlight that will pass us by for the rest of our lives and put it into storage batteries and save it. It is an absurd thing to do because of the prohibitive economics of capturing very large quantities of it for that purpose. The uranium tailings should be mined when they become economical or, in this case, when the breeder reactor becomes economical. The issue is the economics of the breeder, and not whether one mines the tailings right at the moment.

Regarding the issue of cost of the breeder, Dr. Yasinsky's paper has some conflicting statements in it. He refers to the fact that—or at least my interpretation of his testimony is somewhat conflicting. I simply wish to point out that whereas we have sunk $1 billion into the Clinch River reactor already, we should not make decisions today on the basis of sunk costs. One should make economic decisions on the basis of costs to complete the project and weigh the future benefits against the costs to complete. The $1 billion sunk is money down the drain.

This testimony refers to the fact that there is $124 million worth of delivery equipment, and $300 million has been, as he says, costed. On the other hand, he points out that the 5-year delay has cost us some $700 million. In effect, if you subtract the $300 million from the $700 million, it is going to cost $400 million more to complete the breeder reactor today than previously estimated.

Mr. Culler refers in his testimony to the doubling time and the fact that the electricity growth rate is now down to a 28-year doubling time. That of course is based on EPRI figures or EEI figures which have never been known, at least in the last 8 years, to underestimate electrical growth. He points out the advantage, or the nice thing, about this is that the breeder-fuel doubling time can meet that kind of electricity doubling time. Well, that is fortunate in one sense, for the breeder doubling time now is not what people were projecting some years ago. But in another sense it doesn't help you very much because a low doubling time means you are unable to take advantage of the displacement of uranium by plutonium until much later than previously thought. So that argument cuts both ways.

On the statements by Mr. Iacobellis about the breeder will put pressure on OPEC, I simply don't know whether to laugh or cry when I hear statements like that.

There were some questions about breeder safety. You got very one-sided answers. For example, Dr. Culler referred to how fortunate it was that the Clinch River reactor is using stainless steel instead of zircaloy fuel cladding and therefore you don't have the TMI hydrogen generation problem. Of course he failed to mention the fact when sodium is spilled on concrete it interacts with concrete and creates hydrogen, and in many of the accident scenarios that are addressed in the licensing of a breeder, one has to cope with hydrogen generation in breeders just like one does in light-water reactors. In fact, in the design of the breeder at least as of about 1977 the applicants for a license for the Clinch River reactor and Westinghouse, were proposing to accommodate hydrogen generation by venting the secondary containment.

There are other problems with regard to breeders. You got only one side of the safety argument. The other side is that under certain accident scenarios breeders can explode. The concern here is whether you have adequate primary containment in the reactor vessel to contain that explosion. And if one doesn't, then one releases sodium to the secondary containment, which can result in hydrogen generation, and fires, and so forth. And also one releases the vaporized-fuel inventory of the reactor or some fraction of it including plutonium vapors. And then there is the concern as to whether the secondary containment will adequately contain these vapors in the event of sodium fires or a hydrogen explosion.

Mrs. BOUQUARD. You lost me on that one.

Dr. COCHRAN. Floyd was trying to convince you that a breeder reactor is safer than a light water reactor. You will never find that statement in anything the Nuclear Regulatory Commission has written. I don't think you can make that statement. You can design both of them, depending upon how much money you want to invest in them, to whatever degree of safety you want.

Now, there are parameters with regard to breeders that are attractive. He named the ones that are attractive. One can bring out a laundry list of characteristics of breeders that make it appear less attractive than light-water reactors. To simply show one-half of the list is a really biased presentation and I think is unfair to you to just tell you the good things—to tell you what are the good things about breeders without ever identifying the disadvantages.

I am sorry Mr. Lujan is not here. Having seen the other hands on the table, I would like to explain a little more why he should fold.

Another very misleading presentation by Floyd is with regard to the last table in his paper and his continued statements that the breeder is a plutonium bank and is the best place to put the plutonium. If milk were dangerous, you wouldn't feed the milk to cows to produce more milk. You would probably do something about the source of the material.

Floyd makes the point that breeders don't—I think his graph is in terms of net annual consumption and production. In other words, he is telling you how much more plutonium is produced over what is consumed. The issue with regard to nuclear weapons proliferation—there is more than one, but the concern is not the net amount of plutomium produced by the reactor annually, but how much plutonium is taken out every year. A large 1,000-megawatt commercial breeder has a plutonium inventory of 3 to 5 tons, depending upon the design. You take out about half of that every year. You are taking out more plutonium, much more than you would out of a light-water reactor annually, even though the net amount that you breed is not much different.

The more important issue, however, is that in the breeder fuel cycle you have to reprocess that material and recycle it and put it back into reactors, whereas in a light-water reactor you don't have to recycle that material and it remains with the radioactive fission products, at least with some protection for 100 or so years.

So let's don't confuse the issue. The issue is not which one has the highest or lowest net annual plutonium production. The real issue with regard to proliferation is whether one wants to go to a fuel cycle that requires reprocessing or whether one wants to continue to stay with the once-through fuel cycle of the current light-water reactors. In that regard, several of the speakers quoted the NASAP report, the DOE report on nonproliferation, as supporting the view that the breeder, the LMFBR is the best way to conserve energy. Well, that is a given. You don't have to quote NASAP for that. What they didn't bother to quote you is the first recommendation of the NASAP report which says that the once-through fuel cycle is the most proliferation resistant fuel cycle, at least in technical terms, of all of the alternatives. And I would encourage you to go and get a copy of the executive summary of NASAP and at least read on page 5 the first finding and recommendation.

Let me now turn to my testimony.

The specific question now before the Congress is whether to authorize expenditure in fiscal year 1982 of some hundreds of millions of dollars for the Clinch River breeder reactor. In reality, however, the question is whether to push forward during the next several years attempting to develop a commercial plutonium breeder, with total program costs approaching $20 billion. That $20 billion—use whatever number you like—I assumed one-half billion dollars a year for about 40 years. It works out to roughly $20 billion. It is, in short, not a question simply of providing further funding to a low key, ongoing program, but rather of making a long-term commitment, at extremely high cost, to a very dangerous technology which would involve massive flows of nuclear weapons material in the commercial sector. NRDC believes that such a commitment would be an enormous mistake at this time or in the foreseeable future.

There are several important facts to keep in mind about the Clinch River breeder reactor:

First: The primary purpose of any reactor is to generate electricity. The additional purpose of the breeder is to create plutonium, an alternate fuel for uranium. Such an alternate fuel is important only insofar as it is economical. Despite the complexity and higher capital cost of the technology which is employed the breeder simply represents a sophisticated method of heating water with nuclear weapons material.

Second: The plutonium breeder will not reduce American dependence on oil, foreign or domestic, by a single drop. At present, only about 10 percent of our electricity is generated by burning oil, and much of that is for peak demand, often in smaller and older plants. This use of oil will be reduced by conversion of existing plants to coal as required by the national fuel conversion policy and by the replacement of the older plants with new ones using other fuels. Large oil-fired generating plants will not be built in the future in the United States. New baseload nuclear plants may compete with coal—surely will—but not oil.

Another point is that the breeder commercialization will be well into the next century, after which we will certainly not be using oil for electricity production, and so you are simply not going to displace foreign oil. In that regard, I have one of these bumper stickers put out by the Clinch River project: "Step Toward Energy Independence, Clinch River Breeder Reactor Plant Project." The only thing that prevents this from being false advertising is that it doesn't say whether it is a step forward or backward—actually it does.

Third: The need for the plutonium breeder is dependent on the need for electric-generating capacity and, more importantly, on the growth in demand for the existing light-water reactor technology. At the time the CRBR was proposed, electric-power demand was growing at 7 percent per year. There has been a dramatic reduction in the electrical growth rate since the 1973 Arab oil embargo. Last October, the Electric Power Research Institute—never known for underestimating electric growth rates—projected electrical requirements in the year 2000 would be 5.9 plus or minus 1 trillion kWh, just over one-half the estimate made by ERDA 6 years earlier in defense of its breeder program. Similarly, ERDA, in late 1974, had projected 1,200 gigawatts in nuclear power by 2000. The last published DOE estimate was 160 to 200 gigawatts. That is still high. A more reasonable figure is, in my opinion—I am sure I would get disagreement by some of the previous speakers—is 120 gigawatts, or fully a factor of 10 below the old ERDA figure used to support the breeder program.

Fourth, the claimed economic advantage of the plutonium breeder over the presently used LWR is based on the now lost hope that recycling of the plutonium and uranium fuel through reprocessing would be significantly cheaper than mining and enriching uranium and that this savings would offset the higher capital cost of the breeder plant. The cost advantage of the breeder, if any, thus rests on the relative cost of the fuels as compared to the capital cost difference of the two reactors.

The best economic data on breeders today derives from French experience. At least Floyd and I appear to agree on that. The French are now estimating that the Superphenix will cost 2.3 times—my number is 2.3 times—the cost of a French LWR. And here again Floyd and I disagree. I am refering to published figures; Floyd is referring to a private breakfast conversation this morning. The target of the French breeder program is to bring the cost of "mature" breeders down to about 1.75 times the cost of the French LWR. With this cost difference, the plutonium breeder would drive electricity generating prices up by about 40 to 50 percent. Uranium would have to rise to five times current prices, $150 a pound. If we improve the uranium utilization efficiency in LWR's by 50 percent, it would go up even further, to about $300 a pound. At these prices the breeder is unlikely ever to be economical. Of course one can always pick a figure and say that is the kind of figure one would need to make the breeder competitive with the LWR and say that is our goal, but saying that is the goal doesn't make it a goal. You know the old joke that Abraham Lincoln supposedly told, "If a tail is a leg, how many legs would a cow have?" When the answer five was given he would say, "Calling it a leg doesn't make it a leg."

The problem right now is the French Superphenix reactor is costing too much and that is why the French program is slowing down somewhat. Electricite de France realizes they can build five LWR's for the price of two breeders, so they are slowing down their commitments to the follow-on plants and surely they will build less breeder plants than they previously projected.

I think that the economic data on the French breeder program is very much like the economic data on the French and British Concorde program. We are learning today on the basis of their mistakes that it is not wise to go ahead rapidly with breeders at this time because of economic considerations.

When you consider the $20 million cost of a U.S. breeder R. & D. program, which must be factored into any cost/benefit analysis, it is impossible to construct any realistic assumptions that justify spending several hundred million dollars on breeder R. & D. this year. In fact, to make LMFBR appear competitive much before 2030, one must make extreme assumptions regarding each of several key variables: Breeder capital costs, uranium prices, electrical demand, nuclear growth, the social discount rate and so forth. The nuclear industry would call this possibility a class 9 accident—so remote a possibility as to be not worthy of further consideration.

Fifth, a rationale for development of the breeder reactor has been the concern over a potential shortage of uranium fuel for conventional light water reactors. Properly framed, the concern is subsumed in the issue. We have had experience in the past with these cost/benefit analyses. It is fairly clear now that if you look at what it takes to make the breeder economical and then compare those assumptions with current estimates, it is just beyond credibility that all of the assumptions will be met. It is perhaps worth noting that with each new estimate by DOE the uranium resource base has been increasing, not decreasing. DOE now projects 3.2 million tons of proven resources and probable resources at less than $100/lb. and 4.9 million tons when speculative resources are included. And of course there would be additional resources at higher prices of uranium, still competitive with breeders if you use the target cost, the French target cost that I mentioned earlier, 1.75 times the LWR. Even the lower figure exceeds the lifetime fuel requirements of 500 light water reactors of current design, or about four times the commitment to light water reactors through the year 2000. And this would, of course, double, if advanced LWR designs were pushed and the uranium efficiency improved.

Sixth, the design of the Clinch River Breeder Reactor, developed nearly a decade ago, is out of date. That is my opinion. Of course you are going to get opinions on both sides of that issue, particularly by the people that have a vested interest in the program.

There is certainly a lot of debate on that issue. It derives in large measure I believe from the fact that Clinch River was designed—at least in terms of the basic design parameters—you can change the widgets here and there, but the basic parameters were frozen about a decade ago. They were based largely on the basic design parameters used in the FFTF in order not to extrapolate the technology too far and incurred additional risks—financial and technological risks. FFTF is a 1960 vintage breeder technology. So at least in terms of the basic design parameters, this is a very old design.

Mrs. BOUQUARD. Excuse me, Dr. Cochran. If you could, we are going to have to vacate this room in about 10 or 15 minutes. So if you could summarize, we would appreciate it.

Dr. COCHRAN. I will try to finish.

Mrs. BOUQUARD. Certainly we appreciate it.

Dr. COCHRAN. Seventh, the European and Japanese plutonium breeder programs are experiencing serious difficulties in moving toward commercial development. As I mentioned earlier, the French program is being delayed because of cost increases on the Superphenix. And the plutonium breeder programs in the UK, Germany and Japan all appear to be on hold. They are slowing down. I have discussed the data on that in the footnote of my testimony.

Incidentally, I want to correct footnote 7. The FFTF is a 400-megawatt thermal reactor, and not 70 as I indicated.

Finally, the plutonium used and produced by the plutonium breeder, including the CRBR, is directly usable in nuclear weapons. The fresh breeder mixed-oxide fuel, containing 15 to 25 percent plutonium, can be fashioned directly into a nuclear bomb without chemical processing. If a more sophisticated, higher yield, nuclear weapon is desired, a country or subnational group at a cost of $1 to $2 million according to DOE, could chemically separate a bomb's worth, 10 kg, of plutonium from fresh breeder fuel in 3 to 7 days' time. Unlike alternative reactor fuel cycles, the CRBR type poses the maximum risk of nuclear weapons proliferation by countries, and the maximum risk of theft or diversion by criminal or terrorist groups. This is assuming that the technology is already introduced obviating the need to go ahead with a dedicated facility from scratch. I would point out in regard to the Indian bomb the plutonium was from the Cirus Reactor that was processed in their good old breeder reactor reprocessing facility.

The amount of plutonium loaded into commercial-size breeder reactors annually would be sufficient to construct several hundred nuclear weapons, approximately the size of the nuclear weapons stockpiles of the United States or U.S.S.R. in the early 1950's.

The new administration, in the brief time it has been in office has insisted that all Government programs be carefully scrutinized and weighed to determine whether the costs of the program outweigh the expected benefits. Furthermore, it has insisted that the litmus test for energy programs is their viability in a free market economy.

I have attached a copy of an analysis by David Stockman in 1977 to my testimony, where he concludes that the breeder cannot compete with existing nuclear technologies within the time frame contemplated by its advocates without continuing massive subsidies, which is why he is opposed to the breeder. I ask that this statement of Mr. Stockman, this full statement, be included as part of the record.

[See testimony of March 17, 1981, pages 643–761 of this volume.]

Consistent with the philosophy of the new administration, it would be far more appropriate to turn to the private sector, the industries which will use and benefit from the new technology, at least to participate on a realistic basis in its development. The fact that industry participation is now down to about 11 percent of the CRBR cost and zero for the balance of the breeder program reveals the shaky economic ground upon which Clinch River rests. There is simply no reason why the Federal Government should pay virtually the total costs of a demonstration technology which its proponents claim will be economically viable.

It is often argued that the breeder reactor is necessary for true energy independence—again referring to the Oak Ridge, Tenn., bumper sticker—because the technology all but eliminates reliance on finite uranium resources. This is a simple, appealing argument, but it requires one to ignore the following facts. Our energy security problem derives from liquid fuels—oil, not electricity. The United States is not a net importer of uranium today, and two of our closest allies, Canada and Australia, have huge uranium reserves. Spending $20 billion on the breeder will not place the United States any closer to energy independence. Indeed it would divert scarce Federal R. & D. funds from much more promising alternatives to imported oil.

In theory, if the plutonium breeder could be perfected technically—that is, if a high breeding gain could be achieved in advanced reactor designs and if low plutonium inventories could be achieved in the fuel cycle relative to the reactor—then the state of nuclear—I underline "nuclear"—fuel independence still could not be reached until about 2050. In the interim, it would be far cheaper to stockpile uranium.

Using the French "target"—a plutonium breeder costing 1.75 times as much as an LWR—the breeder would cost $900 million more than today's reactors. For this amount, one could purchase 15,000 tons of uranium at current prices. This is 2.5 times the lifetime fuel requirements of today's LWR and 5 times the requirements of an advanced LWR design that could be marketed sooner than the breeder.

Even if one made the wrong free market choice—that is, deployed the breeder rather than improving the LWR and stockpiling uranium—the breeder would increase the electricity available by only a percentage point or two in the event of a hypothetical uranium shortage in 2020. For this level of independence, the nuclear industry would have us build a huge commercial fuel cycle based on nuclear weapons material. Each large commercial nuclear fuel reprocessing plant, processing fuel from some 50 plutonium breeders, would be churning out upwards of 10,000 atomic bombs' worth of plutonium annually, an amount exceeding the entire plutonium inventory in the U.S. weapons stockpile. In 5 years the throughput of just one of these plants would have exceeded the entire U.S. nuclear weapons material inventory invested in some 26,000 nuclear weapons. It is this kind of energy security that we don't need.

It is also argued in favor of the CRBR that other nations are developing breeder technology and will "get ahead" of the United States. First, as noted previously, the pace of breeder development, even in France, is slowing markedly; in other countries, it appears to have come to a virtual halt. The problems of economic viability seem to have caught up with these projects. We would hope that at least one lesson might have been learned from the long SST/Concorde debate: That just because a project is technologically possible is no reason to do it. It is obvious that the United States made the right decision not to proceed with supersonic commercial airplanes, instead going for the more economical wide-bodied jets like the 747. The French and British made a disastrous decision to proceed with Concorde. The advanced LWR could be the 747 of the American nuclear industry, with half the uranium consumption of today's models. Instead of pursuing this technology with a Federal R. & D. cost approximately one-tenth that of the breeder, the DOE Nuclear Division, this committee, the Congress, and now the Reagan administration have systematically gutted every program that appears to compete with the breeder.

The choice is clear. On the one hand, the United States can recapture the reactor market or what there is left of it by improving the LWR. On the other hand, we can invest billions of Federal dollars and build the CRBR, thereby demonstrating to the world that we can build in 1990 what the French built in 1973 a very expensive demonstration plant that can heat water with nuclear weapons material.

There are even better choices. In this regard, it is worth comparing the proposed increases in funding of the breeder reactor with the massive cuts proposed in the conservation and solar programs of the Department of Energy. These programs directly reduce American dependence on foreign energy supplies. Conservation through improving energy productivity can meet our energy problems faster and cheaper than any new program for increasing energy supplies. Despite this, the DOE industrial conservation program, with its proven cost effective track record, is being eliminated by the administration while the breeder budget is being increased. Even solar can produce central station commercial electric energy long before the breeder reactor. Conservation and, in some regions, solar is already competitive economically with central station electric plants.[1] In these circumstances, it makes absolutely no sense to commit massive subsidies to a breeder reactor program with total costs approaching $20 billion when it is so clearly inferior to other energy opportunities available at this time.

In short, the Clinch River Breeder Reactor is a huge economic boondoggle, a massive public works project to boost the morale of an almost comatose industry. The Clinch River breeder has become a symbol in the fight by some DOE and nuclear industry leaders to insure the survivability of the nuclear option. Wiser men in the nuclear industry realize that the United States would have a stronger breeder program if the CRBR were abandoned in favor of the bigger, better breeder. I find it truly remarkable that many in the nuclear industry are willing to destroy the breeder program to preserve the symbol.

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[1] This statement regarding solar has been corrected and clarified for the record by letter of Mar. 13, 1981 from Thomas R. Cochran to Representative Marilyn Lloyd Bouquard.

In closing, let me note that, even assuming the CRBR made sense technically, and that there were any hope that it could lead to a commercially successful technology, it is incomprehensible that the administration should propose increased Federal funding now. The needy in this country are being told that in the interests of economic recovery they must accept billions of dollars of cuts in basic human service programs, decreased food stamp allowances, increased rent contributions for subsidized housing, and cutbacks in child nutrition programs. Can the CRBR really be viewed as more deserving of Federal support than these basic human services? The administration's breeder philosophy parallels that of the late former Pakistani Prime Minister Bhutto, who once said that his country would develop atomic weapons even if we have to eat grass.

That concludes my testimony. I would be happy to answer questions.

Mrs. **Bouquard**. Thank you very much, Dr. Cochran.

Mr. Lowery?

Mr. **Lowery**. Madam Chairman, I didn't have any questions, but since Dr. Cochran speaks so favorably of light water reactors, I have a question for him.

Do you or does the Natural Resources Defense Council advocate further development of light water reactors? And are you on record to that position, you know, officially anywhere?

Dr. **Cochran**. The Natural Resources Defense Council doesn't have a stated policy on nuclear. One can derive, I suppose, the view of the Natural Resources Defense Council by listening to testimony of its senior staff, like that you just heard.

In my opinion, there are much preferred energy alternatives to nuclear. I don't get in a debate over whether there should be a moratorium today or tomorrow, or no new licensing, et cetera. I think the appropriate way to look at it—if you do not like the technology in the short run you should put primary emphasis on energy conservation, improving energy productivity. That is the only alternative. In the longer run, what options will you have to displace nuclear technology will depend on your energy R. & D. priorities. I would place a higher priority on other technologies, particularly the ones that have just been cut by this administration, solar, solar photovoltaics, conservation again, than I would on nuclear technologies, particularly the breeder.

Mr. **Lowery**. So I should not misinterpret those glowing terms in which you spoke of the light water breeder reactor.

Dr. **Cochran**. With regard to advanced nuclear technology, I realize it is going to take some time to get the United States to kick this habit of investing in advanced nuclear technologies. Thus, I think it is appropriate for me to point out what I believe are the preferred technologies, in terms of the economics, proliferation problems, et cetera. That is why I say I favor improving the light-water reactor over the breeder—the previous administration's program of trying to improve the light-water reactor. That was the program that this committee annually would try to cut. That basically summarizes my position.

**Mrs. Bouquard.** Thank you, Mr. Lowery.

Dr. Cochran, on page 10 of your testimony, the bottom of the page, you suggested that there are better ways to displace oil, that there are better alternatives to imported oil. What are these ways and why are they better?

**Dr. Cochran.** Well, I agreed with one of the previous speakers, Dr. Yasinsky, on the criteria that one should use in terms of selecting energy R. & D. programs—priorities for those programs. He mentioned two: Economics and national security. There are of course other things one could mention, but those are two very important ones. The national security problem is——

**Mrs. Bouquard.** Excuse me. I am talking about an alternative to imported oil.

**Dr. Cochran.** I am coming to that. The national security problem is imported oil. The quickest way to reduce the oil imports is to remove subsidies for all energy technologies and to focus in your R. & D. program on energy conservation in the short run. That is the way you are going to get off of the oil imports problem.

The economics, you don't want to address that here, so I will pass on that.

**Mrs. Bouquard.** Are you saying that conservation is the best alternative to imported oil? Is that your answer?

**Dr. Cochran.** Including energy productivity, that form of conservation. Not turning down the lights and freezing in the dark and so forth. Yes, ma'am. In the short run.

**Mrs. Bouquard.** Do you have any statistics to back this up?

**Dr. Cochran.** I would suggest you read some documents, and there was a presentation by Roger Sant of the Carnegie-Mellon Foundation before the Department of Energy's Energy Research Advisory Board at the last meeting with regard to the subsidy issue. I think his report is—I have forgotten the title of it, but the effect of it is if you remove the subsidies, oil imports would drop nearly to zero within a decade.

**Mrs. Bouquard.** But what is the next thing? You said there are alternatives. What are the others?

**Dr. Cochran.** Alternatives to——

**Mrs. Bouquard.** Imported oil.

**Dr. Cochran.** Well, if you want to produce electricity, the present alternatives that compete with energy productivity are not terribly attractive. They are light-water reactors and additional coal. I don't think we are going to need new capacity—any new baseload capacity beyond what is in the pipeline in this next decade.

Looking further ahead, the alternatives are solar, and I put less emphasis on fusion because I think it is going to have some real economic problems like the breeder. In fact, it will be lucky to compete with the breeder.

**Mrs. Bouquard.** In reference to our synfuel program, are you supportive of this program?

**Dr. Cochran.** I am supportive of an R. & D. effort in the synfuel area. I am not supportive of the priorities that the previous administration placed on the synfuels, spending $20 or so billion on the synfuel program and less than $1 billion on energy conservation. I think it has the priorities just backward. I am not opposed to synfuels.

Mrs. BOUQUARD. How about the DOE participation in the synfuel program?

Dr. COCHRAN. Well, I would encourage you to invite Mr. Jonathan Lash from NRDC if you want more information on the synfuel. I don't have any problem with DOE having an R. & D. program in the synfuels area. I think that misses the issue. The issue is what priority are we going to place on synfuels vis-a-vis other R. & D. technology. We have only a limited R. & D. budget. How much should we spend on synfuels versus solar photovoltaics, is the issue. This administration seems to want to cut the solar program by more than half, cut the conservation program more than half, and unfortunately, they want to cut the synfuels program, too. In terms of priorities I would put less emphasis on the synfuel than I would on those other two programs.

Mrs. BOUQUARD. Dr. Cochran, do you think that the proliferation of nuclear weapons is better controlled by denying breeders to the United States while other nations are going ahead or by the United States entering into an international breeder program through cooperative agreements?

Dr. COCHRAN. I think the best way the proliferation problem can be reduced would be for us to set an example for the rest of the world. I don't think that getting into this technology in a big way is going to be a bit helpful with regard to the proliferation problem.

Mrs. BOUQUARD. Do you think our program has been in the least bit helpful in the past 4 years?

Dr. COCHRAN. Yes.

Mrs. BOUQUARD. In what respect?

Dr. COCHRAN. Excuse me.

Mrs. BOUQUARD. Our nonproliferation policy in the last 4 years.

Dr. COCHRAN. In the last 4 years? Yes; I think it has in several respects. Incidentally, there are some aspects of it I disagreed with, so I am not totally in support of the previous administration's nonproliferation program. But the primary thing that was helpful was that it steered the major nuclear programs around the world away from reprocessing for the purpose of recycling plutonium in light-water reactors. It gave people a breathing period to reexamine the issue. In that breathing period, these countries realized that the economics wasn't there to support that technology, and none of them are going ahead with reprocessing for that purpose.

Now, what we need is another breathing period. People need to digest the economics of the breeder a little more. We should defer commitments to the demonstration plant and further commercialization of the breeder and set an example. Let people digest the French data, and they will find the breeder is not going to be economical. Give countries like India less room to argue that their breeder programs are essential for their civil nuclear programs when in fact their breeder programs are used for weapons. It would have the same effect as the abandonment of plutonium reprocessing in light-water reactors has had on the Pakistani program. It makes it clear that the Pakistani program is a weapons program.

Countries would no longer be free to export the technology used for reprocessing. Pakistan has had to go buy it undercover around the world. It will make it more difficult for Iraq to continue their weapons program using the French and Italian nuclear technology.

Mrs. **Bouquard**. On page 13 of your testimony you say: "conservation and, in some regions, solar are already competitive economically"—I want to stress economically—"with central station electric plants."

Dr. **Cochran**. I would like to refer you again to the testimony by the former head of the solar photovoltaic program before the Energy Research Advisory Board, Department of Energy.

Mrs. **Bouquard**. Dr. Cochran, I am referring to your testimony. You say "Even solar can produce central station commercial electric energy long before the breeder reactor." This is your statement.

Dr. **Cochran**. Yes; I am referring you to the source of that information.

Mrs. **Bouquard**. But you made the statement.

Dr. **Cochran**. Yes.

Mrs. **Bouquard**. Now, where is this?

Dr. **Cochran**. Where is it?

Mrs. **Bouquard**. Yes, sir.

Dr. **Cochran**. Where is it economic?

Mrs. **Bouquard**. Yes, sir.

Dr. **Cochran**. Regions of the country like the Southwest.

Mrs. **Bouquard**. I would like a specific site. I might like to do a field trip out there.

Dr. **Cochran**. I will get you that for the record. [See page 319–330.]

Mrs. **Bouquard**. You will submit it.

Dr. **Cochran**. I am not saying I have a—I didn't say in my testimony that there is a generating plant out there cranking away. I said it——

Mrs. **Bouquard**. You said: "Even solar can produce central station commercial electric energy long before the breeder reactor. Conservation and, in some regions, solar are already competitive economically with central station electric plants."

Dr. **Cochran**. I will get you that information for the record.

Mrs. **Bouquard**. I would like the specific site and the complete data on such a location.

Thank you very much.

Dr. **Cochran**. You realize that California utilities are buying central station solar facilities and are not buying breeders.

Mrs. **Bouquard**. I appreciate this information. Thank you for your testimony.

The subcommittee stands ajourned.

[Whereupon, at 12:56 p.m., the committee was adjourned.]

[Additional statement for the record submitted by Thomas Cochran follows:]

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March 26, 1981

Mr. Thomas B. Cochran
Natural Resources Defense Council, Inc.
1725 "I" St., N.W. - Suite 600
Washington, D. C. 20006

Dear ~~Mr. Cochran~~ Tom:

Thank you for your letter of March 13, 1981 responding to my request for confirmation of your March 4th testimony stating that in some regions, central station solar electric is already economically competitive. While your letter does not clearly say so, apparently you are acknowledging that you have no support for this statement, a view that is consistent with the information available to me.

In that context, referencing the testimony of Mr. Paul Maycock, you acclaimed the commitment of Southern California Edison to the installation of the majority of its new capacity as renewable energy systems. Interestingly, his testimony makes it very clear that the use of these renewable energy systems is restricted to "a very limited set of utilities". He defines this set as those that are highly dependent upon fossil fuels, that must have new capacity within the next ten years and that have difficulty in expanding their nuclear capacity. California is cited by Mr. Maycock as a prime example fitting these criteria.

It seems clear that you are referring to situations where viable alternatives are prohibited and unusual economic circumstances make renewable energy sources more attractive. This is hardly a sound argument against the use of nuclear energy for generating electricity.

In addition you reference EPRI's report "Overview and Strategy: 1981-1985 R&D Program Plan" for the early commercialization and market penetration of solar thermal-electric and photovoltaic systems. Interestingly, the projected time for market penetration is very near to the time when a decision might likely be made for the first truly commercial breeder reactor in this country. Your argument ignores the fact that a number of power producing breeder reactors are already operating throughout the world and the Clinch River Breeder Reactor is scheduled to be operational at about that time. The $20 billion program and run-out costs you cite appear to be consistent with the total Government involvement in civilian nuclear programs for the last 25 years and reflect sunk cost. Rather than conserving our resources it would seem that ignoring this investment would be highly wasteful. Future breeder reactors beyond the

Thomas B. Cochran
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Page 2

Clinch River plant are anticipated to be primarily financed by private concerns and are currently projected to be competitive around the turn of the century. Of course, the economics of breeder reactors can not be separated from that of Lightwater Reactors since they will symbiotically operate together as a system.

You have often criticized nuclear proponents for what you view as a lack of consistency and integrity in their arguments. I suggest that a better approach might be for you to focus on the character of your own positions.

Sincerely,

MARILYN L. BOUQUARD, Chairman
Subcommittee on Energy Research
and Production

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March 13, 1981

Rep. Marilyn Lloyd Bouquard
Chairperson, Subcommittee on Energy
Research and Production
House Committee on Science & Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Rep. Lloyd:

In my March 4th testimony before your Subcommittee, I made the following statement:

> Even solar can produce central station commercial electric energy long before the breeder reactor. Conservation and, in some regions, solar are already competitive economically with central station electric plants.

Quite properly, you questioned my statement that solar is already competitive economically with central station electric plants. As I noted in my response to you at the time, this statement was based on my recollection of testimony by Paul Maycock before DOE's Energy Research Advisory Board at our February 5th meeting. Until recently, Paul was Director of DOE's Solar Photovoltaic Program. I have since received transcripts of that presentation and the pertinent pages are enclosed.

As noted in the transcripts, Southern California Edison and PG&E have teamed up with Westinghouse to build some 25 Gw of photovoltaics in the next 10 years. This represents a case where traditional alternatives are either unavailable or too expensive. Paul tells me that Southern California Edison's Cal-Coal Project is coming in at 12-14 cents per Kwh because of environmental restrictions and because it will take some 12 years to complete the project. Southern California Edison has announced that the majority of new capacity -- 300 Mw to 500 Mw -- will be renewable energy systems. Because Southern California Edison's problems are not unique, we can anticipate other utilities following Southern California's lead.

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I have also enclosed a discussion of solar thermal electric and photovoltaic systems from EPRI's "Overview and Strategy: 1981-1985 R&D Program Plan" (October 1980). Here EPRI concludes that "economic feasibility has yet to be demonstrated for photovoltaic devices in large-scale terrestrial systems" (p. 129), although the goal for commercial systems -- initial market penetration in 1988 and significant market growth in 1993 (p. 129) -- is comparable to, if not shorter than, the time it will take to bring in CRBR or a new nuclear plant ordered today. Therefore, my conclusion that

> it makes absolutely no sense to commit massive subsidies to a breeder reactor program with runout costs approaching $20 billion when it is so clearly inferior to other energy opportunities available at this time

is justified.

Please accept this correction and clarification of my remarks, share this letter with others on the Committee, and include it in the record.

Sincerely,

Thomas B. Cochran

enclosures

# Transcript of Proceedings

UNITED STATES DEPARTMENT OF ENERGY

MEETING OF THE ENERGY RESEARCH ADVISORY BOARD

Volume 1

Washington, D.C.

February 5, 1981

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now selling commercial 2-foot square ribbon modules. Their investment in this exceeds or investment by a factor of 10. We have invested the order of $3 million and the researchee production development kind of part of the Mibil Tyco work, they have invested in the order of $38 million so far; have a 1 megawatt to 2 megawatt plant ready to go; have been shipping products to their customers for about six months in-house and are now ready to make commercial sales of ribbon.

So, something that was a research curiosity when we started the program in '74 is now a commercial product. Again, the price isn't down significantly because the first Mobil plant is very small, but at a 10 megatwatt plant, the ribbon technology can meet our goal.

Then we took another ribbon technology that doesn't use a shaping guide, it uses a very special growth technique that is called dendritic sheet growth. This is the Westinghouse process.

Westinghouse just recently decided to go into the business and they went in a big way. They looked around and said who are our customers in energy and they found out that they were central utilities. So they went to four of their central utility customers and two bought in on a 10-year, 25 gigawatt goal development process for making dendritic web an economic reality. Two clients are Southern Cal Edison and Pacific Gas and Electricity in

California. And so this is the kind of impetus that began to cause the Solar Photovoltaic Energy Advisory Committee to say in addition to the distributed scenario; that is, use on your own roof, your own house, your own factors, that there could also be a pervasive central use in some utilities.

Now, it's a very limited set of utilities. It has to be a utility that presently has a fair amount of diesel or natural gas peaking and a utility that must have capacity in the next 10 years that's not saturated with capacity, and a utility that has difficulty in growing its next nuclear reactor or it's next pole plant and if you want to find those kind of utilities, just go to the state of California. And they are beginning to discuss and serious commit to alternative technology for their generation.

Now, the solar cells can be made from dendritic web and the good news here, whereas the ribbon that Mobil Tyco makes is kind of limited to about 12 percent efficiency at the moment, which is good news, it used to be 7 or 8, they are now at regular runs at 12 with special crystals coming out at 14. The state of the art in the single crystal area is now about 15 percent efficiency on a regular basis.

Dendritic web can go as high as 16, 16.5 percent efficiency and the theoretical limit is like 22 percent.

# OVERVIEW AND STRATEGY
## 1981–1985 Research and Development Program Plan

Prepared by

The EPRI Policy Planning Division
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

October, 1980

The Electric Power Research Institute (EPRI) came into being in 1972 under the voluntary sponsorship of the nation's electric utility industry—public, private, and cooperative. EPRI was formed to conduct a broad program of research and development in technologies for electric power production, transmission, distribution, and utilization that is economically and environmentally acceptable. EPRI's activities are coordinated with those of the federal government, state agencies, individual utilities and research organizations in other countries.

EPRI's goals evolved from objectives originally stated by the Electric Research Council in 1971. Refining them and establishing program priorities is an annual process that involves the combined efforts of EPRI's utility advisory committees, Advisory Council and technical staff. This year's Overview contains a statement of the EPRI research and development strategy and program emphasis.

be solved. The transport of the biomass material tends to be costly and consumes considerable energy. The utilization of biomass could also result in air quality problems from increased particulates.

Currently, biomass (mainly wood waste) is used to supply a little less than 2% of present U.S. primary energy requirements. This figure could rise if the price of competing fuels increases disproportionately. The conversion of biomass into liquids like gasohol is currently receiving much publicity, but the existing processes are expensive. Unless the economics of biomass production, conversion, and transportation can be improved, its use for electricity generation will be limited to direct combustion of agricultural, forestry, industrial, and municipal waste. By 2000, approximately 2.8 GW are estimated to be generated from biomass.

## Solar-Thermal Electric

Solar-thermal central receiver concepts include three basic utility applications: stand-alone plants with thermal storage; repowering of existing oil- and gas-fired power plants; and solar-fossil hybrid plants. In all these applications, tracking heliostats (mirrors) reflect and concentrate sunlight to a central receiver where it heats a fluid (e.g., water/steam or air) to drive a steam or gas turbine. Backup power to operate the unit during cloudy periods or at night would be from thermal storage for the stand-alone plant or from the combustion of oil- or a coal-derived liquid for the latter two systems.

Figure 79 shows the schedule for present and proposed large solar-thermal utility related projects in the United States. The federal solar-thermal program has emphasized development of Rankine-cycle systems for both stand-alone and repowering applications. A 10 MW(e) pilot plant is now under construction in southern California in partnership with two electric utilities. The heat transfer fluid is water/steam and thermal storage will provide stand-alone capability. Information concerning repowering and industrial process heat installations will also be obtained from this project, due to be operational in early 1982.

EPRI studies indicate that the Brayton-cycle solar-fossil hybrid concept appears to be one of the more promising of the solar-to-electricity concepts. Hybrid solar-thermal plants appear to be suited best to meet peaking and intermediate load requirements and initial applications would probably be in the Southwest. Little or no cooling water is required with this option, and a high degree of plant reliability and operating flexibility is expected from the Brayton-cycle concept. Components of this system have been tested at 1 MW(th) (receiver) and a bench-scale (modified gas turbine) size range.

Further development of the solar-fossil hybrid system requires the construction and operation of complete systems. EPRI is funding the development of a Full System Experiment utilizing a successfully tested air cooled receiver; this will be operational in early 1982. A 10 MW(e) scale Brayton-cycle experimental power plant is being considered in which testing could begin in 1985. The next logical step in the concept development would be a demonstration plant in the 50 MW(e) size range.

Six utility repowering projects now in the conceptual design stage are being funded by DOE. One or two demonstration power plants in the 25-50 MW(e) range developing from these studies could optimistically achieve system operation in 1985, given significant federal funding. After a reasonable test program and with supporting data from the 10 MW(e) pilot plant, decisions concerning a possible first commercial power plant order could begin to be made in the late 1980s. This assumes achievement of technical and operational goals and confidence in plant cost estimates.

The major cost item in the commercial solar-thermal power plant is

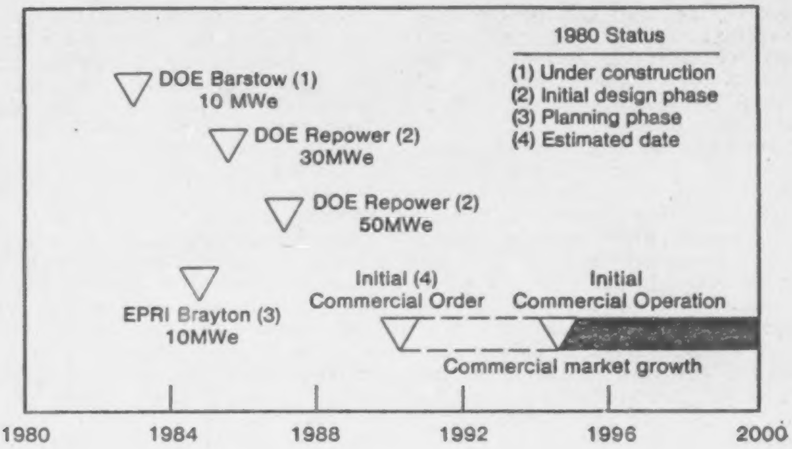


Figure 79. Proposed Large Solar-Thermal Utility Related Projected in the United States

that of the heliostat field. A number of heliostat design concepts have been under development with funding from DOE; the initial costs projected by the contractors indicated the DOE goals of \$65/M$^2$ installed (1978 dollars) could be achieved when units are ordered in commercial quantities. If this DOE goal can be met, solar thermal will be competitive with a number of utility oil- or gas-fired installations. Subsequent heliostat cost assessment studies by Battelle-NW (DOE-funded), A.D. Little, Inc. (EPRI-funded), and General Motors (Solar Energy Research Institute-funded) indicate that installed costs below \$100/M$^2$ (1979 dollars) are probably achievable for commercial orders of 25,000 units per year or more.

Estimates show that 2.0 GW of solar-thermal power generation capacity for utility use could be operational by 2000; this includes stand-alone repowering and solar-fossil hybrid concepts that meet cost and performance goals.

Total energy, cogeneration, and industrial retrofit solar-thermal systems are also under development. A number of site-specific and process-specific design studies are underway in which electric power generation is part of the concept. Significant market potential exists for solar-thermal systems in these applications. Industrial firms are large users of gas and liquid fuels and are impacted by the fuel change requirements of the National Energy Act of 1978.

## Photovoltaic

Photovoltaic cells offer the following advantages for generation of electricity:

- Cooling water is generally not required for nonconcentrating systems because the light is converted directly into electricity at or near ambient temperature.

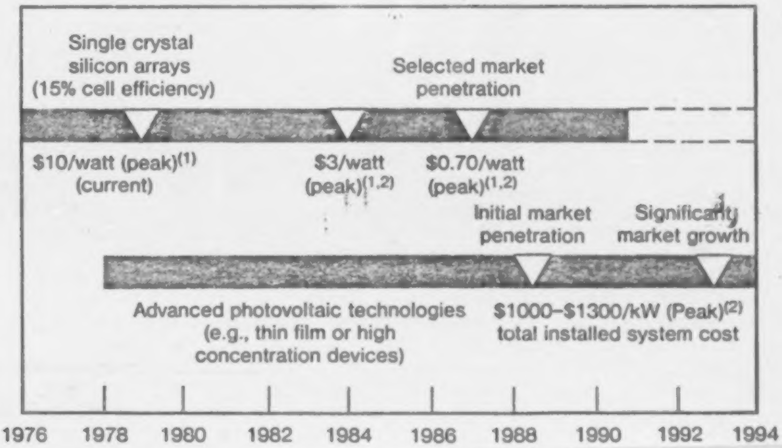
- Nonconcentrating systems can function with diffused as well as direct sunlight; therefore, they will operate over a wider range of ambient conditions.

- Cells convert sunlight directly to electricity with no moving parts and with no intermediate energy forms.

However, current high cost of single-crystal silicon panels (approximately $10/peak watt) precludes widespread application of these cells.

Other approaches hold greater promise of economic viability. Thin-film devices (e.g., copper sulfide/cadmium sulfide, indium phosphide, ternary chalcogenides, amorphous silicon, and others) in flat plate systems might become viable if array efficiencies of 10% or more can be combined with cell costs under $30 per square meter (1979 dollars). High concentration systems which involve concentrations greater than 100:1 also appear promising if cell conversion efficiencies above 30% can be achieved. EPRI is investigating a concept called thermophotovoltaic conversion. This approach employs concentration of sunlight and shifting of the spectrum to infrared wavelengths. Recent experimental results have been attractive, leading to expanded program activity. Technical and cost targets are identified in Figure 80 for each of the three options identified above.

A current DOE photovoltaic goal is to manufacture by 1986 single-crystal silicon or other types of arrays at a cost of .70¢/peak watt (1980 dollars). At that cost, the arrays could penetrate an identifiable but limited specialty market. A more significant market penetration would occur if a second DOE goal can be met. This calls for total installed photovoltaic system cost in the range of $1000-$1300/kW (peak). This total system cost goal assumes a market and, consequently, a manufacturing production rate of several hundred megawatts per year. Although progress has been made over the last several years, economic feasibility has yet to be demonstrated for photovoltaic devices in large-scale terrestrial applications.



(1)Cost of arrays, does not include balance of systems costs.
(2)Target costs in 1980 dollars.

Figure 80. Photovoltaic System Development DOE Program Targets

Achievement of the DOE goals will require proof of equipment reliability in a utility environment plus demonstration of viable mass production methods. The likelihood of researchers meeting the technical and economic targets described above is currently difficult to assess. Assuming that the 1990 targets can be met, several hundred megawatts of installed photovoltaic capacity could be in place by 2000.

| Resource Definition | Resource Quantity GW for 30 Years |
|---|---|
| Evaluated (identified and resource evaluated) | 23 |
| Inferred | 97 |
| Total | 120 |

Figure 81. Estimate of Hydrothermal Resources

## Geothermal

Present U.S. geothermal capacity is 820 MW, with another 120 MW under construction. Of this amount, 800 MW of geothermal capacity is of the dry steam type located at Pacific Gas and Electric's Geysers Power Plant in California and 20 MW is hydrothermal (hot water). An additional 1083 MW are being planned for dry steam and 210 MW for hydrothermal. Technology for using dry steam reservoirs is improving, and the industry is learning how to use hydrothermal reservoirs. The number of dry steam reservoirs is limited, so research is being directed toward development of other types of geothermal energy, with emphasis on hydrothermal. EPRI's geothermal research is concentrated mainly on development of hydrothermal resources. Major emphasis is on binary cycles, which expand the resource base by making it possible to use lower temperature resources. Although many technical problems need to be overcome, estimates show that about 16 GW of geothermal capacity could be developed in the western states by 2000.

An estimate of hydrothermal resources, excluding those located in national forests and parks, is in Figure 81.

Figure 82 shows that most electricity grade hydrothermal resources are located in the western United States. Many economic and technical questions must be resolved before an assessment of the total generating capacity from this resource can be made. Nevertheless, a capacity of over 50 GW could possibly be developed in the long-range future.

A third source of energy from the earth's crust is geopressured systems, estimated at about 12% of the total U.S. geothermal resource base. These reservoirs lie under the U.S. Gulf Coast and other sedimentary basins in the United States. Oil exploration has helped to map the extent and depth of the geopressure regions, but records of geopresure yields are scant because drillers have not extended their operation to these formations.

## Fusion

Although scientific feasibility of fusion, the nuclear process in which atomic nuclei are combined to form heavier nuclei with the release of energy, is demonstrated in the stars, the challenge on earth is to provide this energy resource on a scale and with control to be applied for electric power production. This challenge has occupied the attention of a world community of scientists and engineers since the early 1950s. Presently, the scientific community believes that demonstration of a controlled thermonuclear burn is close at hand.

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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THURSDAY, MARCH 5, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 8 a.m., in room 2318, Rayburn House Office Building, Hon. Marilyn Lloyd Bouquard (chairman of the subcommittee) presiding.

Mrs. Bouquard. The hearing will come to order.

A bright and early good morning to all you distinguished ladies and gentlemen.

This morning we also have a distinguished panel to consider another critical nuclear issue, that is, the future of the nuclear fuel cycle and, particularly, reprocessing. Reprocessing of nuclear fuel has been another casualty of the past administration's visceral, antinuclear policy based on vague fears of weapons proliferation without recognizing international realities. No one has argued that nonproliferation is an undesirable goal, rather that there are many more productive avenues to controlling nuclear materials and technology. Avenues which are chiefly institutional. Unfortunately, we have offended friend and foe alike over the past 4 years by forcing them to renegotiate nuclear agreements without concentrating on sensitive technology or recognizing, for instance, that the Pakistani situation is significantly different from that of Argentina. What we have produced from this naive approach is a proliferation of nuclear suppliers over whom we have little influence because our preeminence in the nuclear field has been eroded.

Today, we expect to receive good advice on how to reopen the reprocessing option in proper phase with the breeder reactor timetable. We expect to hear about the future role of the Barnwell nuclear plant and why and when we should reprocess spent fuel. Down the road, we must ultimately look to a breeder-burner economy wherein the United States and other nuclear nations will provide the resources for developing nations to brighten their energy futures with nuclear plants and without increasing the dangers of proliferation of nuclear weapons.

Gentlemen, I am looking forward to your testimony and, again, I appreciate your appearance at this very early hour. This is what I call Mike McCormack committee hours because I remember as a freshman most of our hearings were at 8, and I felt that, if this is the way the Congress operates, they are a hard-working group of people. I still think they are, but I am glad we have renegotiated our hours.

Our witnesses today are Dr. Chauncey Starr, an old friend of this subcommittee and vice chairman of the Electric Power Research Institute, Mr. John Gray, president of International Energy Associates Ltd., and Dr. James Colby, senior vice president of Allied Chemical Corp.

Dr. Starr, please proceed with your testimony.

We have your complete testimony so, if you would like to summarize your testimony, feel free to do so.

## STATEMENT OF CHAUNCEY STARR, ELECTRIC POWER RESEARCH INSTITUTE

Dr. STARR. Thank you, Madam Chairman.

The letter of invitation requested that, for those on the committee who might not be fully aware of what the chemical processing cycles are, I start with a little tutorial of what is involved. So I have appended to my testimony an extract of a paper written last year for the Pontifical Academy which does do that.

It is a primer on the whole nuclear fuel cycle and how it functions. It is written for the nonprofessional individual. I will not go through that primer. For those on the committee who would like to get immediately familiar with what we are talking about, please turn to figure 1 of this appendix. Figure 1 shows what is called the once-through cycle. It is at the very end of the appendix attached. What figure 1 shows is that natural uranium is put into a fuel enrichment plant; then fabricated into fuel suitable for the nuclear reactor operation; and when it comes out of the nuclear reactor it gets stored. That is the once-through cycle which has been the common item of discussion in the past several years.

If you will turn to the next page to figure 2, you will see in greater elaboration what is meant by a closed-fuel cycle. A closed-fuel cycle goes through the same initial process. When the irradiated fuel comes out from the nuclear core, it is then sent into a chemical plant. The plutonium is extracted and is put into fresh fuel. It is this closed cycle which forms the recycle discussions for light water reactors and the normal closed cycle that goes with the fast reactor.

What comes out of the closed cycle is some radioactive waste and some uranium that has not been used, which is then sent back into the enrichment plant.

I will not go into the details described in this primer attached to the testimony. This was intended as a tutorial piece for other purposes and I think you will find it useful.

I would like to now talk about the principal subject as to why we should undertake chemical processing of spent fuel and when should we do it.

As a preamble to the discussion of the programmatic aspects of chemical processing of spent nuclear fuel, I believe it would be useful to present a conception of the industrial scale of the activities involved. A full-scale chemical processing plant, of which Barnwell is typical, can handle about 1,500 metric tons of spent fuel per year. It would cost about $1 to $1½ billion to construct such a plant, depending on fuel preparation and waste facilities. Such a chemical processing plant would have three outputs: about 1,400 tons per year of slightly enriched uranium—approximately 0.9 percent uranium-235 (I will recall for you that natural uranium is 0.7 percent), about 10 tons per year of plutonium, and a small amount of radioactive fission products in a chemical solution. A plant of this type is based upon the Purex process, which has been used for decades to separate military grade plutonium, and for which the technology is well in hand. This process will permit the recovery of 99 percent of the uranium and 99.9 percent of the plutonium contained in the fuel.

A chemical processing plant of this size could take the annual output of about 60 light water reactors. A nominal light water reactor is a 1 gigawatt size. That is 1,000 megawatts at 65-percent capacity factor.

This should be compared with the present U.S. nuclear plant capacity of about 55 GWe, with a prospective capacity in 1990 of 110 GWe and, in the year 2000, of about 200 gigawatts. Thus, one commercial chemical plant could take the annual output of spent fuel of our present nuclear capacity and eliminate the need for new away-from-reactor storage facilities; two plants would be required to handle the output in 1990; and three plants by the year 2000.

Of some relevance is the non-U.S. worldwide magnitude of nuclear power development. There is now about 100 GWe of nuclear capacity outside our country, about 180 GWe planned for 1990, and about 350 GWe for the year 2000. These worldwide figures have policy relevance if the United States wishes to restore its role in the international management of plutonium fuels. Since by the end of the century the U.S. production of plutonium will be about 30 percent of the free world production, elimination of U.S. reprocessing would not significantly reduce the worldwide availability of plutonium. It has often been proposed that the international management of plutonium fuel be based on a system in which the large nuclear weapons nations receive spent nuclear fuel from the powerplants of the developing world in exchange for providing the developing countries with fresh U-235-enriched fuel. Thus, if the U.S. share of such an international arrangement were about one-third of the output of developing country power stations, by the year 2000, the United States would not need just three chemical plants, but five.

Where would the separated plutonium go? The plutonium output of the processing plants could be stored by the Government until the issues of future use are resolved, or recycled as a fuel in light water reactors, or used as initial inventory for future fast reactors. Only a modest amount is needed for this latter purpose, as the inventory of a fast reactor is about 4 tons of plutonium per GWe, as compared with the annual output of 10 tons of plutonium of our nominal chemical plant. It is evident that the plutonium output of the light water reactor systems, both nationally and internationally, will be more than ample to inventory fast reactors for a very long time.

Although it is the conventional wisdom that the cost of chemical processing is sufficiently large to make the extraction of plutonium for recycling as a fuel into light water reactors not attractive at the present time, it is evident to most of us who study the technical and economic trends that sometime early in the next several decades the economics of recycle may be sufficiently attractive that this might become a desirable part of the nuclear fuel cycle. As a measure of the economic pressure which may develop, the 10 tons per year of plutonium output from our first commercial processing plant represent an annual nominal value of $250 million with the plutonium fuel valued at $25 per gram. In addition, the slightly enriched uranium contained in the spent fuel, 0.9 percent of U–235, has an equal value of about $250 million. These values will increase as uranium ore prices rise. Moreover, because plutonium and uranium recycle reduces the need for fresh fuel by about 39 percent of the current once-through cycle, the need for additional investments in enrichment plants and ore supply is substantially reduced. Third, the cost of storage of the waste products discharged by the processing plant will likely be much less than the cost of storage of unprocessed spent fuel, both because of the concentration and because of the highly diminished content of plutonium, which is one-thousandth of the original content. Therefore, the current economic value of the annual output of such a chemical plant represents about one-half billion dollars per year. On a cumulative basis, the value of the slightly enriched uranium in the spent fuel already in storage is approaching $1 billion, and an equivalent value would be attributable to the plutonium in terms of its fuel contribution in a recycle situation. By the year 2000, the cumulative value of the uranium and the plutonium will reach about $10 billion in present dollars. This value will increase as uranium ore prices increase. Thus, the economic values, both cumulative and annual, will likely make processing very attractive sometime in the coming decades.

Another relevant factor in considering the chemical reprocessing program is the leadtime required to build such plants and establish acceptable industrial operation. Even with the existence now of a technology for the Purex process, a new plant of commercial size would take about 10 years to build and place into operation with reasonable and expeditious administrative procedures for licensing and construction. Thus, if we were to start now to place the United States in a posture of being able to handle both domestic and international spent fuel deliveries, we would have to initiate a full-scale program now and accelerate it as soon as we had the learning experience of operation. It is for this reason that the utility industry has urged the rapid demonstration of a full-scale industrial processing plant for handling light water reactor spent fuel.

Our national policy during the past several years on the eventual disposition of spent fuel was based on the egregiously mistaken notion that if reprocessing of such fuel were stopped in the United States, the rest of the world would follow suit. This policy presumably arose from the naive logic that the prevention of plutonium separation from spent fuel would be a major contribution to reducing the worldwide proliferation of nuclear weapons, even though no weapons have ever been made from civilian power fuel. Unfortunately, it has taken many years of internal discussion and debate to expose the fallacy of this official policy of self-denial. Both domestically and internationally, this posture of our Government has been interpreted as a ploy to stop the development of nuclear power both in the United States and in the developing world. This chemical processing halt has jeopardized the future of the fast reactor; has completely disoriented the waste management program; and has placed additional potential pressures on the world uranium supplies. As is now well known, the International Nuclear Fuel Cycle Evaluation Report explored this subject and very clearly stated that the position of the United States in these matters would not be followed by any other nations.

An unfortunate consequence, of course is that, during this interval of several years, the United States has lost its ability to play a significant role in the deployment of nuclear power worldwide. Further, with this demonstration that the United States would no longer be a reliable supplier of nuclear technology and nuclear fuel, the other countries of the world were stimulated to pursue their nuclear programs independently much faster than would otherwise have occurred, with the result that they have now developed the skills and technology which were previously concentrated in the hands of the nuclear weapons powers. Unfortunately, the whole effort has been destructive to the domestic energy interests of the United States, and very counterproductive for limiting the spread of technological skills which might at some future time be diverted to the production of nuclear weapons. The achievement of a common nonproliferation policy is now more difficult, as a result.

During this period of the no-reprocessing doctrine, the spent-fuel alternatives that were considered were either permanent surface storage or permanent burial of the spent fuel. While both are physically possible, it was felt by many of us that they were both unlikely to be an acceptable doctrine for any length of time. As I pointed out above, the economic values of the stored plutonium and the partially enriched uranium are cumulatively very high, and this would eventually create a situation where the fuel value of the contained material would drive many countries of the world to extract these valuable substances. In addition, we were deeply concerned that spent fuel storage spread all over the world would eventually provide an easily accessible source of plutonium for military purposes, because of the low level of radioactivity associated with very longtime stored fuel. It is for this reason that we have urged that there be an international management policy of bringing spent fuel back to the major nuclear weapons countries for permanent handling, rather than encouraging local spent fuel permanent storage. There are, of course, further negative aspects associated with indefinite spent fuel storage. The cost of surface storage, constant monitoring, and protection of such storage centers would become a permanent nonproductive burden. In addition, the small volume of vitrified waste is both cheaper and easier to dispose of safely than the much larger volume of spent fuel containing all the plutonium. Many of us believe that it was injudicious, both from the point of view of the world's resources and the point of view of public protection, to seriously consider such permanent storage of spent fuel, either on the surface or in the ground.

The issue then becomes one of establishing a spent fuel processing program with regard to timing and magnitude. Certainly, one could store spent fuel, as we are doing now, in special surface storage facilities near powerplants for some decades. However, for many reasons, this is not a prudent national policy: First, the leadtime required to get industrial chemical processing of spent fuel into being is such that we should be undertaking this now to meet our future needs; second, the economic values will continue to accumulate in the spent fuel as already described; and, finally, the absence of major processing facilities within the United States would remove its ability to play any kind of significant role in an international program for managing plutonium systems. While many of these issues are intangible in their importance, they, nevertheless, all emphasize the need for being energetic and aggressive in developing our chemical processing capabilities to handle the spent fuel output of nuclear powerplants.

What should we be doing now? The immediate need is to initiate the industrial demonstration of light water reactor fuel processing on a full-scale basis. To do so requires a sure extrapolation of present technology. Such a demonstration is important to permit the more rapid deployment at a later date of commercially viable full-scale processing plants and waste treatment facilities. This demonstration program should seek to achieve plutonium conversion to oxide for incorporation in new fuel; should include the vitrification facilities for concentrating radioactive wastes; and should seek to improve the cost-effectiveness and performance of the full-scale process.

As a distinctly separate program, we should pursue the research and development of a closed processing and refabrication cycle appropriate for fast reactors. As this committee has heard many times, the fast reactor fuel cycle must be completely closed for the successful operation of fast reactor systems. This fuel cycle development should be conducted in parallel with the development of the fast reactor. We have had the time to do this in a rational and technically efficient way because the plutonium output from the light water reactor spent-fuel chemical process will provide the first inventory requirements of the initial group of fast reactors. The objective of a fast reactor fuel cycle program should be first, compatibility of the closed processing system with reactor fuel design and overall system performance, recognizing both the near-term and the long-term objectives of fast reactor systems. For the next several decades, we are not concerned with the ability of the fast reactor to efficiently breed new fuel, because the supply of plutonium from light-water reactor systems worldwide will be so large that there will be no limit to the expansion of fast reactors imposed by the absence of plutonium. In fact, during this period, fast reactors will incinerate the worldwide inventory of excess plutonium until the systems of thermal and fast reactors approach a balance. The initial generations of fast reactors will produce much less excess plutonium than present light-water reactors. Of course, in the extremely long term, the fast reactor fuel cycle should be developed to maximize its fuel production rate. Obviously, the best of all R. & D. objectives would be the development of a fuel processing and refabrication technique which meets both the near-term and the long-term objectives of the fast reactor system.

A second objective of the R. & D. program should be the development of diversion-resistant systems which would make it difficult to extract pure plutonium for weapons purposes. The Civex processes reviewed by me and others in 1978 indicated the feasibility of such an objective. This would certainly assist in the long-term evolution of an international arrangement for the management of nuclear power fuels and for minimizing the relationship between civilian power objectives of a nuclear fuel cycle and the military objectives of weapons manufacture. We must recognize that energy resource-poor nations see the fast breeder as the ultimate route to electrical energy independence, but we do have time to create the basis for a safe international management system.

It is important that we emphasize the distinction between the two chemical processing objectives; that associated with the handling of spent fuel from light-water reactors and that associated with the fast reactor fuel cycle. While it is possible to use the Purex process and present technology for the fast reactor fuel cycle, it is so far from optimum for that particular application that I believe it represents an unnecessary distortion of both objectives to try to combine them. As you may know, this separation of technologies is already underway in the United Kingdom, where the proposed Windscale plant will handle fuels from the present commercial category of power reactors, and a fast reactor fuel cycle development is being demonstrated on a pilot scale at Dounreay, where the United Kingdom fast reactor development is centered. Similar programs are also underway in France.

It is evident that progress in the chemical processing of spent fuel is the key to opening the ways for a rational policy on the efficient use of uranium resources for light-water reactors, for the fast reactor development, for the waste management program, and for an international plutonium management regime. The chemical processing decisions should not prudently be deferred. A firm program objective is now more important than the current level of effort.

I would like to repeat that point—a firm program objective is now more important than the current level of effort.

I believe that the technical resources of the national laboratories and industrial organizations in the United States are sufficiently extensive and sufficiently capable that a sound program to develop the U.S. domestic strength and our international posture in the fuel cycle program can yet be achieved. I certainly hope that Congress encourages a rational approach to this matter and stimulates the initiation of these activities.

Thank you.

[The prepared statement of Dr. Starr follows:]

EPRI

# CHEMICAL PROCESSING OF SPENT NUCLEAR FUEL: WHY AND WHEN?

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TESTIMONY
BEFORE THE
SCIENCE AND TECHNOLOGY COMMITTEE
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
U. S. HOUSE OF REPRESENTATIVES
WASHINGTON, D. C.
MARCH 5, 1981

ELECTRIC POWER RESEARCH INSTITUTE

# CHEMICAL PROCESSING OF SPENT NUCLEAR FUEL: WHY AND WHEN?

As a preamble to the discussion of the programmatic aspects of chemical processing of spent nuclear fuel, I believe it would be useful to present a conception of the industrial scale of the activities involved. A full-scale chemical processing plant, of which Barnwell is typical, can handle about 1,500 metric tons of spent fuel per year. It would cost about one to one-and-a-half billion dollars to construct, depending on fuel preparation and waste facilities included. Such a chemical processing plant would have three outputs: about 1,400 tons per year of slightly enriched uranium (approximately 0.9 percent U-235), about ten tons per year of plutonium, and a small amount of radioactive fission products in a chemical solution. A plant of this type is based upon the Purex process, which has been used for decades to separate military-grade plutonium, and for which the technology is well in hand. This process will permit the recovery of 99.0 percent of the uranium and 99.9 percent of the plutonium contained in the fuel.

A chemical processing plant of this size could take the annual output of sixty light water reactors (1 GWe each at 65 percent capacity factor). This should be compared with the present U.S. nuclear plant capacity of about 55 GWe, with a prospective capacity in 1990 of 110 GWe, and in the year 2000, of about 200 GWe. Thus, one commercial chemical plant could take the annual output of spent fuel of our present nuclear capacity and eliminate the need for new away-from-reactor storage facilities; two plants would be required to handle the output in 1990; and three plants by the year 2000.

Of some relevance is the non-U.S. worldwide magnitude of nuclear power development. There is now about 100 GWe of nuclear capacity outside our country, about 180 GWe planned for 1990, and about 350 GWe for the year 2000. These worldwide figures have policy relevance if the U.S. wishes to restore its role in the international management of plutonium fuels. Since by the end of the century, the U.S. production of plutonium will be about 30 percent of the free world production, elimination of U.S. reprocessing would not significantly reduce the worldwide availability of plutonium. It has often been proposed that the international management of plutonium fuel be based on a system in which the large nuclear weapons nations receive spent nuclear fuel from the power plants of the developing world in exchange for providing the developing countries with fresh U-235 enriched fuel. Thus, if the U.S. share of such an international arrangement were about one-third of the output of developing country power stations, by the year 2000 the U.S. would need not just three chemical plants, but five.

Where would the separated plutonium go? The plutonium output of the processing plants could be stored by the government until the issues of future use are resolved, or recycled as a fuel in light water reactors, or used as initial inventory for future fast reactors. Only a modest amount is needed for this latter purpose, as the inventory of a fast reactor is about four tons of plutonium per GWe, as compared with the annual output of ten tons of plutonium of our nominal chemical plant. It is evident that the plutonium output of the light water reactor systems, both nationally and internationally, will be more than ample to inventory fast reactors for a very long time.

Although it is the conventional wisdom that the cost of chemical processing is sufficiently large to make the extraction of plutonium for recycling as a fuel into light water reactors not attractive at the present time, it is evident to most of us who study technical and economic trends that sometime early in the next several decades the economics of recycle may be sufficiently attractive that this might become a desirable part of the nuclear fuel cycle. As a measure of the economic pressure which may develop, the ten tons per year of plutonium output from our first commercial processing plant represents an annual nominal value of $250,000,000 (fuel value of $25 per gram). In addition, the slightly enriched uranium contained in the spent fuel (0,9 percent of U-235) has an equal value of about $250,000,000. These values will increase as uranium ore prices rise. Moreover, because plutonium and uranium recycle reduces the need for fresh fuel by about 39 percent of the current once-through cycle, the need for additional investments in enrichment plants and ore supply is substantially reduced. Third, the cost of storage of the waste products discharged by the processing plant will likely be much less than the cost of storage of unprocessed spent fuel, both because of the concentration, and because of the highly-diminished content of plutonium (one-thousandth of the original content). Therefore, the current economic value of the annual output of such a chemical plant represents about one-half billion dollars per year. On a cumulative basis, the value of the slightly enriched uranium in the spent fuel already in storage is approaching $1,000,000,000, and an equivalent value would be attributable to the plutonium in terms of its fuel contribution in a recycle situation. By the year 2000, the cumulative value of the uranium and the plutonium will reach about $10,000,000,000 (present dollars). This value will increase as uranium ore prices increase. Thus, the economic values, both cumulative and annual, will likely make processing very attractive sometime in the coming decades.

✓ Another relevant factor in considering the chemical reprocessing program is the lead time required to build such plants and establish acceptable industrial operation. Even with the existence now of a technology for the

Purex process, a new plant of commercial size would take about ten years to build and place into operation with reasonable and expeditious administrative procedures for licensing and construction. Thus, if we were to start now to place the U.S. in a posture of being able to handle both domestic and international spent fuel deliveries, we would have to initiate a full-scale program now and accelerate it as soon as we had the learning experience of operation. It is for this reason that the utility industry has urged the rapid demonstration of a full-scale industrial processing plant for handling light water reactor spent fuel.

Our national policy during the past several years on the eventual disposition of spent fuel was based on the egregiously mistaken notion that if reprocessing of such fuel were stopped in the United States, the rest of the world would follow suit. This policy presumably arose from the naive logic that the prevention of plutonium separation from spent fuel would be a major contribution to reducing the worldwide proliferation of nuclear weapons, even though no weapons have ever been made from civilian power fuel. Unfortunately, it has taken many years of internal discussion and debate to expose the fallacy of this official policy of self-denial. Both domestically and internationally, this posture of our government has been interpreted as a ploy to stop the development of nuclear power both in the U.S. and in the developing world. This chemical processing halt has jeopardized the future of the fast reactor; has completely disoriented the waste management program; and has placed additional potential pressures on the world uranium supplies. As is now well known, the International Nuclear Fuel Cycle Evaluation report explored this subject and very clearly stated that the position of the U.S. in these matters would not be followed by any other nations.

An unfortunate consequence, of course, is that during this interval of several years, the U.S. has lost its ability to play a significant role in the deployment of nuclear power worldwide. Further, with this demonstration that the U.S. would no longer be a reliable supplier of nuclear technology and nuclear fuel, the other countries of the world were stimulated to pursue their nuclear programs independently much faster than would otherwise have occurred, with the result that they have now developed the skills and technology which were previously concentrated in the hands of the nuclear weapons powers. Unfortunately, the whole effort has been destructive to the domestic energy interests of the U.S., and very counterproductive for limiting the spread of technological skills which might at some future time be diverted to the production of nuclear weapons. The achievement of a common non-proliferation policy is now more difficult, as a result.

During this period of the no-processing doctrine, the spent fuel alternatives that were considered were either permanent surface storage or permanent burial of the spent fuel. While both are physically possible, it was felt by many of us that they were both unlikely to be an acceptable doctrine for any length of time. As I pointed out above, the economic values of the stored plutoniun and the partially enriched uranium are cumulatively very high, and this would eventually create a situation where the fuel value of the contained material would drive many countries of the world to extract these valuable substances. In addition, we were deeply concerned that spent fuel storage spread all over the world would eventually provide an easily accessible source of plutonium for military purposes, because of the low level of radioactivity associated with very-long-time stored fuel. It is for this reason that we have urged that there be an international management policy of bringing spent fuel back to the major nuclear weapons countries for permanent handling, rather than encouraging local spent fuel permanent storage. There are, of course, further negative aspects associated with indefinite spent fuel storage. The cost of surface storage, constant monitoring, and protection of such storage centers would become a permanent non-productive burden. In addition, the small volume of vitrified waste is both cheaper and easier to dispose of safely than the much larger volume of spent fuel containing all the plutonium.

Many of us believe that it was injudicious, both from the point-of-view of the world's resources and the point-of-view of public protection, to seriously consider such permanent storage of spent fuel, either on the surface or in the ground.

The issue, then, becomes one of establishing a spent fuel processing program, with regard to timing and magnitude. Certainly, one could store spent fuel, as we are doing now, in special surface storage facilities near power plants for some decades. However, for many reasons, this is not a prudent national policy: first, the lead time required to get industrial chemical processing for spent fuel into being is such that we should be undertaking this now to meet our future needs; second, the economic values will continue to accumulate in the spent fuel as already described; and, finally, the absence of major processing facilities within the United States would remove its ability to play any kind of significant role in an international program for managing plutonium systems. While many of these issues are intangible in their importance, they, nevertheless, all emphasize the need for being energetic and aggressive in developing our chemical processing capabilities to handle the spent fuel output of nuclear power plants.

What should we be doing now? The immediate need is to initiate the industrial demonstration of light water reactor fuel processing on a full-scale basis. To do so requires a sure extrapolation of present technology. Such a demonstration is important to permit the more rapid deployment at a later date of commercially-viable full-scale processing plants and waste treatment facilities. This demonstration program should seek to achieve plutonium conversion to oxide for incorporation in new fuel; should incorporate the vitrification facilities for concentrating radioactive wastes; and should seek to improve the cost-effectiveness and performance of the full-scale process.

As a distinctly separate program, we should pursue the research and development of a closed processing and refabrication cycle appropriate for fast reactors. As this Committee has heard many times, the fast reactor fuel cycle must be completely closed for the successful operation of fast reactor systems. This fuel cycle development should be conducted in parallel with the development of the fast reactor. We have the time to do this in a rational and technically efficient way, because the plutonium output from the light water reactor spent-fuel chemical process will provide the first inventory requirements of the initial group of fast reactors. The objective of a fast reactor fuel cycle program should be first, compatibility of the closed processing system with reactor fuel design and overall system performance, recognizing both the near-term and the long-term objectives of fast reactor systems. For the next several decades, we are not concerned with the ability of the fast reactor to efficiently breed new fuel, because the supply of plutonium from light water reactor systems worldwide will be so large that there will be no limit to the expansion of fast reactors imposed by the absence of plutonium. In fact, during this period, fast reactors will "incinerate" the worldwide inventory of excess plutonium, until the systems of thermal and fast reactors approach a balance. The initial generations of fast reactors will produce much less excess plutonium than present light water reactors. Of course, in the extremely long term the fast reactor fuel cycle should be developed to maximize its fuel production rate. Obviously, the best of all R&D objectives would be the development of a fuel processing and refabrication technique which meets both the near-term and the long-term objectives of the fast reactor system.

A second objective of the R&D program should be the development of diversion-resistant systems which would make it difficult to extract pure plutonium for weapons purposes. The Civex processes reviewed by me and others in 1978 indicated the feasibility of such an objective. This would certainly assist in the long-term evolution of an international arrangement for the management of nuclear power fuels and for minimizing the relationship between civilian power objectives of a nuclear fuel cycle and the military objectives of weapons manufacture. We must recognize that energy resource-poor nations see the fast breeder as the ultimate route to electric energy independence, but we do have time to create the basis for a safe international management system.

It is important that we emphasize the distinction between the two chemical processing objectives: that associated with the handling of spent fuel from light water reactors and that associated with the fast reactor fuel cycle. While it is possible to use the Purex process and present technology for the fast reactor fuel cycle, it is so far from optimum for that particular application, that I believe it represents an unnecessary distortion of both objectives to try to combine them. As you may know, this separation of technologies is already underway in the United Kingdom, where the proposed Windscale plant will handle fuels from the present commercial category of power reactors, and a fast reactor fuel cycle development is being demonstrated on a pilot scale at Dounreay, where the UK fast reactor development is centered. Similar programs are also underway in France.

It is evident that progress in the chemical processing of spent fuel is the key to opening the ways for a rational policy on the efficient use of uranium resources for light water reactors, for the fast reactor development, for the waste management program, and for an international plutonium management regime. The chemical processing decisions should not prudently be deferred. A firm program objective is now more important than the current level of effort.

I believe that the technical resources of the national laboratories and industrial organizations in the U.S. are sufficiently extensive and sufficiently capable that a sound program to develop the U.S. domestic strength and our international posture in the fuel cycle program can yet be achieved. I certainly hope that Congress encourages a rational approach to this matter, and stimulates the initiation of these activities.

Thank you.

# # # # #

# APPENDIX
TO THE
TESTIMONY ON
# CHEMICAL PROCESSING OF SPENT NUCLEAR FUEL: WHY AND WHEN?

CHAUNCEY STARR

EXTRACTED FROM ~~PAPER O~~N:

## A PERSPECTIVE ON CURRENT REACTOR TECHNOLOGIES

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PRESENTED AT THE

STUDY WEEK ON MANKIND AND ENERGY: NEEDS, RESOURCES, HOPES
PONTIFICAL ACADEMY OF SCIENCES
VATICAN CITY, ROME
NOVEMBER 10, 1980

# A PERSPECTIVE
# ON
# CURRENT REACTOR TECHNOLOGIES

by
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## 1. Nuclear Power Plants - Introduction

A conceptual way of viewing all nuclear reactor systems is to consider them essentially as electricity-producing black boxes. The basic input to such a device is an external stock of natural uranium. In a light water reactor, which will be the predominant nuclear plant on a worldwide scale until the end of this century, it is necessary to use slightly enriched uranium in order to maintain the fission chain reaction. The fraction of the fissile isotope of uranium--uranium-235--must be quadrupled from 0.7% in natural uranium (the rest is the nonfissile or fertile isotope $^{238}U$), to about 3%, in order to extract the required amount of energy over the residence time of the fuel in the reactor's core. The selective enrichment of the fissile isotope fraction is carried out in a uranium enrichment plant, which is the largest component of the nuclear fuel cycle as it exists today. A generic basic description of annual reactor operation is shown in Figure 1, based on a recent report (1).

The nuclear chain reaction results in three major products or outputs. About 75% of the initial fissile uranium-235 input is destroyed by the fission process, thus releasing large amounts of thermal energy, which is recovered in the turbine generators to produce electricity. The fissioned $^{235}U$ is split into two smaller nuclei (referred to as fission products) and between two and three additional neutrons, which are mostly used to perpetuate the chain reaction. The fission products, which are highly radioactive and decay eventually with a half life of about thirty years, are the major waste products of the reactor operation and need to be disposed of. Nuclear physicists now specify that a highly radioactive substance that has decayed over approximately twenty half lives, [i.e., its activity has decreased to one-millionth (1/1,000,000) of its original value] has become relatively harmless and does not pose a greater danger to life than naturally occurring radioactive sources. In the case of the nuclear high level waste--the concentrated stream of fission products from the chain reaction--isolation from the biosphere for a period of 600-900 years is required in order to reduce the residual radioactivity to such levels. It is only when the fission products stream includes a small amount of long-lived radioactive heavy elements, due to incomplete separation, that the required waste storage periods are considerably increased.

The third major product of the nuclear chain reaction is the newly produced or "bred" fissile elements. Some of the neutrons emitted in the fission process are absorbed by the fertile fuel isotope and after a series of two radioactive decays produce new and relatively stable elements that can be utilized as nuclear fuel in other power plants. When the major fertile component of the fuel is the uranium isotope $^{238}U$, the bred fissile element is plutonium. When fertile thorium atoms are employed as diluents in advanced fuel cycles, the bred fissile isotope is uranium-233.

In most of the reactors described here, a large fraction, about 50%, of the newly produced fissile isotopes are destroyed as they themselves are fissioned, and only the remaining fraction is discharged from the reactor at the end of its annual operating cycle.

A schematic of the fuel cycle is shown in Figure 2. The "front end" of the fuel cycle, from the mining of the uranium ore until insertion into the reactor, includes three major components: uranium mining and milling, uranium enrichment, and fuel element fabrication.

The "back end" of the fuel cycle, includes all activities involving the discharged fuel elements. A current mode of operation is the open or throwaway fuel cycle. The discharged spent fuel is stored intact in properly cooled storage basins for a long time, and eventually sent to a permanent burial site. As the title implies, all the potentially useful components in the spent fuel, i.e., the remaining unfissioned uranium and the bred plutonium, are sent to the waste repository, together with the fission products. This scheme avoids the need for chemical separation.

On the other hand, such a cycle is extremely wasteful of fuel resources, which is particularly significant in this conservation-conscious period, and results in a large economic loss. It has been calculated that the value of the remaining uranium in spent U.S. fuel elements (disregarding the potentially greater value of the bred plutonium in breeder reactors) already amounts to about 1.5 billion, 1980 dollars (2).

The other generic kind of a fuel cycle involves a closed loop, where the spent fuel is chemically separated, the fission products are concentrated and sent to the waste disposal plant, and the useful uranium, or both the useful uranium and the bred plutonium, are recycled into the fuel fabrication plant at the front end of the reactor cycle, and are reconstituted as new fuel elements. Physics calculations according to (1) and (3) have indicated that uranium recycling would save 22% of the uranium required in the throwaway fuel cycle, and both uranium and plutonium recycling would save between 35% and 40% of the external annual fuel requirements of the once-through cycle. Savings of up to 25% of the uranium enrichment demand would occur in the case of complete recycling, thus reducing the size of the required fuel enrichment plant. Another potential use of the separated fissile material is to inventory a different kind of a nuclear plant--the breeder reactor--which is more efficiently operated on plutonium based, rather than uranium fields.

## 2. Classification of Reactors and Fuel Cycles

Several generic families of reactor technologies exist in the world today and can be classified according to the fuel, chain reaction moderator, and coolant utilized. Recent descriptions of the various reactor concepts can be found in (1), Volume 9 of (3) and (4). The most widely commercialized concept is the light water reactor (LWR), which comes in two distinct subfamilies cooled with pressurized or boiling water. These reactor concepts, which evolved in the U.S. and later in the USSR, are based on the use of low-enriched uranium, 3% uranium-235, as basic fuel input, thus requiring fuel enrichment technology, and an ordinary, or light, water for maintaining the chain reaction and extracting heat from the reactor core. More than 80% of all operating nuclear plants today are based on this technology.

The second major family of commercial nuclear plants existing today are the gas-cooled reactors (GCRs), built mostly during the 1950s and 1960s in Britain and France. These reactors are based on natural or slightly enriched input uranium fuel; however, they use graphite as the moderating material in the reactor core, and extract the fission heat by helium or carbon dioxide gas flow through the reactor. This technology is now slowly being phased out in favor of the LWR.

A modern offshoot of the older gas cooled reactors is the high temperature gas reactor (HTGR) which operates on medium (about 20%) or highly enriched uranium, is moderated by graphite and cooled by helium gas. Two relatively small demonstration plants now operate in the Federal Republic of Germany (FRG) and in the U.S. As its name implies, the HTGR operates at higher coolant temperatures than the other reactor families, and thus, could find useful applications as a source of high temperature heat for coal gasification, as proposed in the FRG, for steelmaking, as suggested in Japan, and for district heating as constructed in the USSR.

The third commercial reactor concept existing today is the Canadian Natural Uranium Deuterium Reactor (CANDU). This technology is currently based on the use of natural uranium. The fuel elements are held in pressure tubes in a calendria arrangement, instead of in a thick-walled pressure vessel, as in the LWR plants. The moderation of the chain reaction and heat extraction from the core are accomplished by heavy water (enriched in the deuterium isotope) instead of the natural (or light) water as in the LWR. As CANDU reactors are manufactured in smaller sizes than the LWRs--500 to 750 MW (e) vs. 900 to 1300 MW (e) ranges as pressure tubes construction is simpler and less technically demanding than pressure vessel fabrication, and as heavy water production is relatively easier than uranium fuel enrichment, this technology is perceived as the likeliest route for independent nuclear power development by the newly developed and industrializing nations. Both

*India and Argentina* are actively developing such reactors as the future mainstay of their nuclear power programs, and Pakistan, Brazil and Rumania are attempting to develop such capabilities.

Several other advanced converter reactor concepts (ACRs) have been proposed over the past 30 years but have not progressed beyond paper studies and small demonstration projects. These include the spectrum shift converter reactor (SSCR), the light water breeder reactor (LWBR), and the fast mixed spectrum reactor (FMSR).

Further on the reactor evolutionary chain stands the fast breeder reactor (FBR). A comprehensive discussion of this technology was recently published (5) and (6). Unlike the converter reactor discussed above, the breeder produces annually slightly more bred fissile material than its cycle consumes to maintain the chain reaction. The term "fast" in the reactor's name applies to the energy of the fission neutrons. Whereas the moderator in the convertor reactor slows the neutron energies down to low or "thermal" values, the "fast" reactor core does not include any moderator material, and the chain reaction is maintained at high or "fast" neutron energies which are especially suitable for efficient fissioning of plutonium-based fuels. The fast breeder reactor is designed so that there is a net loss of fissile material in the reactor core. Unlike the converter reactors, the breeder's core, however, is surrounded by a "blanket" of fuel elements, in which additional fissile material is bred, due to interaction with the excess neutrons produced in the reactors' core. The design of the breeder reactor is optimized so that the net fissile production in the blanket slightly exceeds the net annual loss of fissile material in the core, thus providing a positive net production for the reactor plant. This material balance, based on data from (5) as optimized for different reactor sizes, is shown in Figure 3. The excess fissile production, discounting losses in the chemical separation process can be set aside annually, and over a period of 15-35 years may accumulate so that a new reactor plant can then be started. The time required for a breeder reactor to produce sufficient excess fuel to start up a new plant is referred to as the doubling time. It is usually required that the breeders doubling time be similar to the electric demand annual growth rate, so that in the 21st century, when these reactors are utilized for bulk electricity generation, sufficient FBR capacity could be installed to meet the increasing demand. As an example, a relatively low electric demand growth rate of 2.5% per year would imply a breeder doubling time of 28 years. This doubling time is well within the capabilities of the current breeder reactor technologies. The relationship between the required doubling time and net annual fissile production is shown in Figure 4, as computed from data (5).

The breeder reactors now developed are predominantly based on the plutonium-fueled and sodium-cooled liquid metal fast breeder (LMFBR) concept. Several medium-size 250-600 MW (e) demonstration plants operate today, and additional larger-size plants are proposed or are under construction. Recent surveys of FBR programs have appeared in (7)-(9). Two other breeder concepts, the gas-cooled fast reactor (GCFR) and the molten salt breeder (MSBR), have not progressed beyond laboratory experiments. The main development trend of the industrial nations has been the reactor progression from the LWR to the FBR, while intermediate technologies, which have been considered as potential alternates, have not yet been commercialized, nor has their manufacturing infrastructure yet been established.

All the above-mentioned reactors can operate on the conventional uranium-plutonium fuel cycle or on the uranium-thorium-U-233 fuel cycle. Each of these fuels could be utilized in the open-ended or throwaway mode, or in the fuel recycle mode. The fissile enrichment of the fuel can be varied from natural (0.7% fissile), to low, medium, or high (above 20%) enrichments. This fissile content could be made up of the $^{235}U$ isotope only, or mixes of $^{235}U$, $^{233}U$ and $^{238}U$ (which are referred to as denatured fuels), or mixes of fissile uranium and plutonium isotopes. Combining the number of reactor families with the number and mode of operation of the various fuel cycles, we obtain a large number of nuclear power plant variants, which describe an almost continuous spectrum of reactor performance characteristics.

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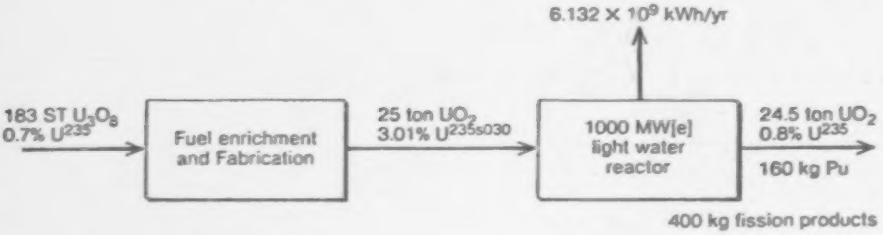
ANNUAL MASS BALANCE FOR A 1000 MW[e] LWR


$6.132 \times 10^9$ kWh/yr
183 ST $U_3O_8$
0.7% $U^{235}$
Fuel enrichment and Fabrication
25 ton $UO_2$
3.01% $U^{235}$s030
1000 MW[e] light water reactor
24.5 ton $UO_2$
0.8% $U^{235}$
160 kg Pu
400 kg fission products

Once-Through Fuel Cycle
70% Annual Capacity Factor
0.2% $U^{235}$ Tails Assay

FIGURE 1

ILLUSTRATIVE CLOSED FUEL CYCLE

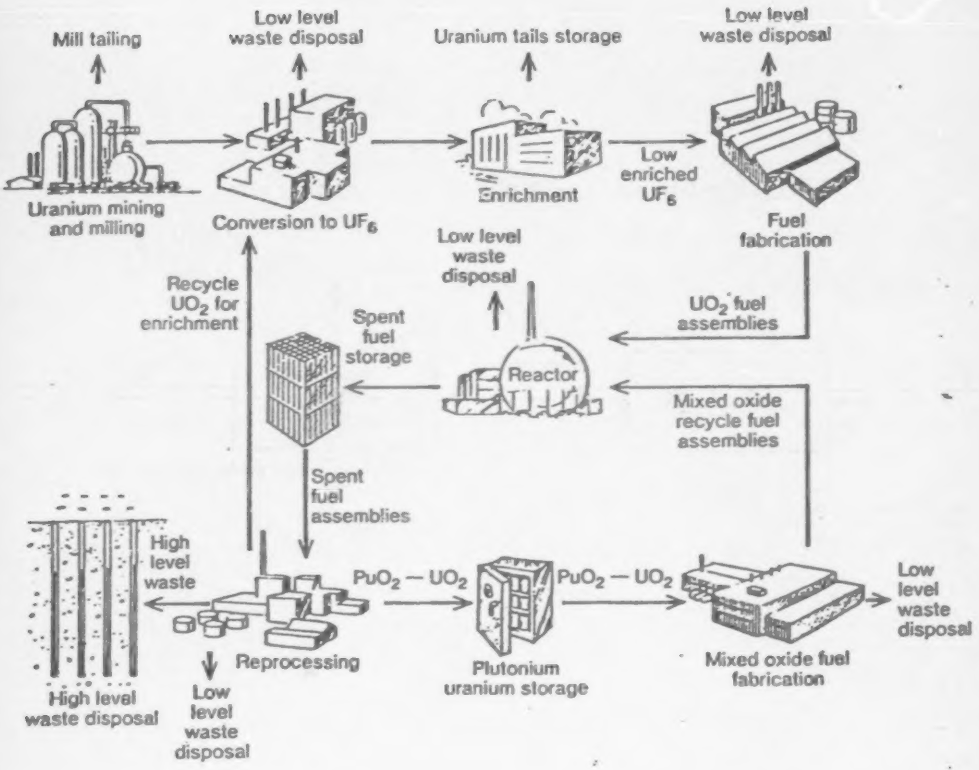

Mill tailing
Low level waste disposal
Uranium tails storage
Low level waste disposal
Uranium mining and milling
Conversion to UF$_6$
Enrichment
Low enriched UF$_6$
Fuel fabrication
Low level waste disposal
Recycle UO$_2$ for enrichment
Spent fuel storage
Reactor
UO$_2$ fuel assemblies
Mixed oxide recycle fuel assemblies
Spent fuel assemblies
High level waste
PuO$_2$ — UO$_2$
PuO$_2$ — UO$_2$
Low level waste disposal
Reprocessing
Plutonium uranium storage
Mixed oxide fuel fabrication
High level waste disposal
Low level waste disposal

FIGURE 2

VARIATION OF INTERNAL & NET BREEDING GAIN
OF OXIDE FUELED LMFBR WITH PLANT SIZE

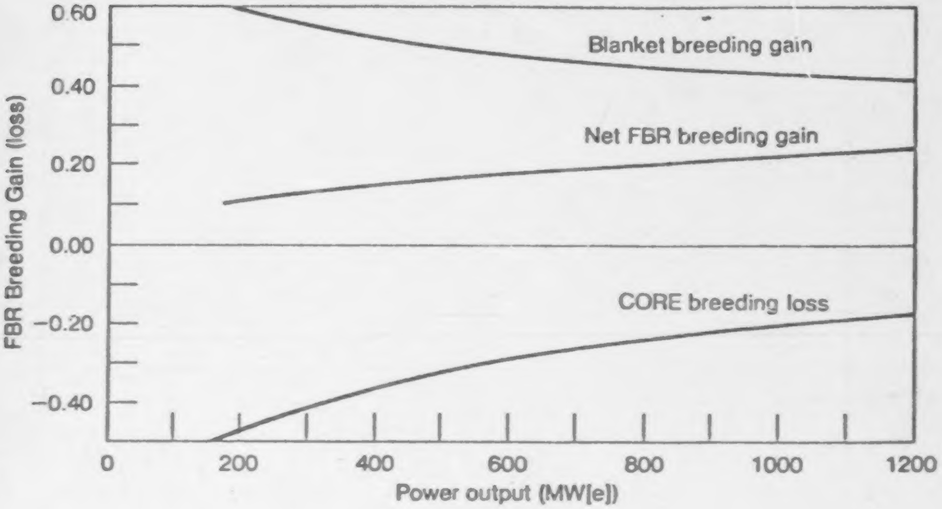


FIGURE 3

RELATIONSHIP OF ANNUAL FISSILE GAIN & DOUBLING TIME
FOR BREEDER & CONVERTER REACTORS

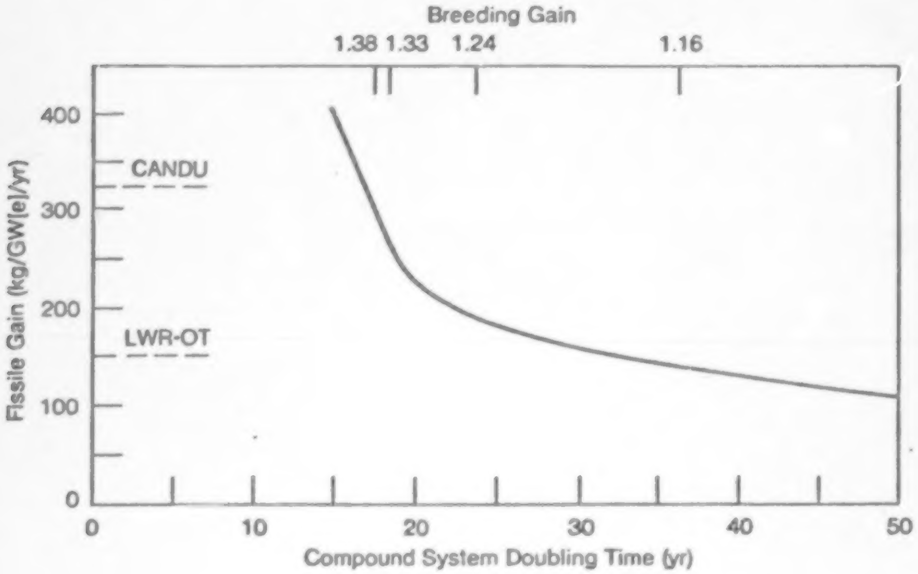


FIGURE 4

Mrs. **Bouquard**. Thank you very much, Dr. Starr. I appreciate your thoughtful and very succinct testimony. I am going to distribute copies of the appendix to your testimony to all of the members of our committee. I think it is very basic to the issues, and it certainly will help all of us, including new members on our committee, so I thank you for your complete testimony.

Before we hear from Mr. Gray, I would like to recognize the ranking minority member of our committee, Mr. Lujan, for any opening remarks that he might have.

Mr. **Lujan**. I have no opening remarks, Madam Chairman. I will be interested in listening to the rest of the testimony, and I will have some questions later.

Mrs. **Bouquard**. Thank you very much.

Mr. Gray?

## STATEMENT OF JOHN E. GRAY, INTERNATIONAL ENERGY ASSOCIATES LIMITED (IEAL)

Mr. **Gray**. Thank you, Madam Chairman.

The particular matters on which I have been asked to comment are:

The importance of fuel reprocessing to the viability of light water reactors, timing requirements for reprocessing capacity for both breeder development and breeder commercialization;

Differences in reprocessing for LWR and breeder reactors, reprocessing needs for various scenarios of LWR, burner, and breeder-reactor growth;

The effect of these scenarios on the inventory of available plutonium; and

The advisability of and difficulties perspectively associated with entering into international cooperative efforts for reprocessing spent fuel and managing plutonium.

I will comment on these matters in that order and then summarize my views. What I propose to do is simply highlight some of the thoughts expressed in my written testimony and go to my conclusions, if I may.

Mrs. **Bouquard**. Without objection, your complete testimony will be made a part of the record. Please proceed.

Mr. **Gray**. Thank you very much.

The success of the nuclear option in meeting the electrical portion of the future demand for energy in the United States is dependent upon the efficiency with which we use our natural uranium resources. The capability to reprocess the spent nuclear fuel generated by light water reactors is fundamental in this regard.

We can recognize the existence of about 500,000 tons of producible uranium reserves, further characterized in the testimony here. This fits with all DOE and other authoritative analyses on the availability of uranium resources and suffice it to say that the development of probable potential resources, as well as higher cost category reserves and resources in the next 20 to 30 years, may triple the producible amount of uranium available to us in the United States. However, the supply-and-demand balance will become increasingly marginal as well as costly after the end of this century.

The most recent DOE forecasts of U.S. nuclear power growth are for an installed capacity of 160 to 200 GWe by the year 2000 and 290 to 460 GWe by the year 2020. There are those in the industry who believe that, while these forecasts may seem to be reasonable in the light of events over the past 4 years, they could turn out to be on the low side. For example, 400 GWe in the year 2000 is possible, and this figure could double by the year 2020. This presumes, however, that there is an adequacy of nuclear fuel, and underlines the necessity for concern with regard to the possibility of marginal supply situations and the necessity to develop efficient options.

Two major options for extending uranium resources are the implementation of uranium and plutonium recycle and the development of the fast breeder reactor. Both of these alternatives require that spent nuclear fuel be reprocessed. While recycle could extend supportable nuclear capacity by almost 50 percent, as you know, the liquid metal fast breeder reactor could extend supportable capacity by almost two orders of magnitude, or 10,000 percent, and allow the nuclear option to continue indefinitely.

Now in order for recycle to be implemented, it would be necessary to have operational reprocessing plants and a 1,500 metric-ton-per-year plant, such as that at Barnwell, would service the spent fuel, resulting from approximately 50 to 60 GWe of LWR capacity.

Assuming the DOE nuclear growth forecasts discussed already, approximately four Barnwells could be used to capacity by the end of the 1990's if one were to pursue recycle. Such an array of plants would be required to work the substantial spent fuel backlog built up by then.

I note the buildup of spent fuel from LWR's by the year 2000 and the year 2020, the amounts being 70,000 and 180,000 metric tons, respectively—these equating to cumulative plutonium discharges of 450 and 1,200 metric tons of fissile plutonium, respectively.

The importance of reprocessing this substantial mine of spent fuel which will be discharged by LWR's in the future can be interestingly viewed in terms of current oil import costs. The potential uranium-related energy equivalent involved, assuming import costs of $35 per barrel, are 10.5 and 27 billion barrels of oil, respectively, costing $367 and $945 billion in 1981 dollars, and reprocessing for deployment of the breeder would amplify these values.

It is always interesting to me the magnitude of the numbers that can be generated as one looks at the perspective energy values that we are fooling around with here, which importantly are known values in hand and the difference between having a resource which can be further developed using available manufacturing processes, as opposed to being resources you have not yet found is fundamental to good, sound energy planning. In defining the spent fuel that comes out of LWR as a mine, it is as if you had a mine in hand where you know exactly what is there and how to get at it, and this is rather fundamentally different than the normal problem of finding resources.

Turning to the deployment of LMFBR's, it is obvious that we must have reprocessing of spent fuel from LWR's to get started on our LMFBR's. The numbers are not new. It is interesting to note, however, that the excess plutonium which would be bred annually in the early breeders corresponds approximately to 3.3 percent or close to what electricity growth rates may be in the year 2000 to 2020. If the breeder is to be the future nuclear option and if that option is to bear a substantial share of electricity demands, then earliest possible deployment is suggested. This would allow maximum advantage to be taken of breeder and breeder reprocessing technology advances and could eliminate the need for considering the use of recycle even for a limited period.

Dealing with the question of reprocessing of LWR spent fuel and breeder reactor spent fuel, I note simply that there are distinctions between these two categories of fuel, but the reprocessing of the breeder reactor spent fuel is not perceived as a major problem.

The projected high burnup in the core may require modifications to LWR spent-fuel reprocessing plant designs. The high burnup and high-plutonium content will impose stringent handling and transportation problems.

I don't here emphasize the proliferation-related issues which Chauncey Starr so adequately did emphasize and discuss treatment for.

The stringency of the handling in transportation systems relates indirectly to the nonproliferation question.

Turning to the question of the effect of these scenarios on the inventory of available plutonium, it is my understanding that there are about 11 metric tons of separated plutonium available for the U.S. civilian breeder programs. It is also my understanding that this amount is substantially committed for use in the fast flux test facility and the zero plutonium production reactor. Thus, there is no substantial inventory of plutonium known to be available for commercial programs or for any of the scenarios earlier referred to.

I might add that this is not an easy subject to tie down with a high degree of specificity. We have, otherwise, been involved in efforts that entail or are attempting to be definitive on this point, and I find, in trying to get an exact figure, that it is extremely difficult to get one that I could present as being a consensus. Notwithstanding, this is where I came out for purposes of this testimony that there is no inventory.

Regarding the advisability of entering into international cooperative arrangements for reprocessing spent fuel and managing plutonium, I have earlier expressed relevant views before this committee. They are found in the Rockefeller Foundation report of 1978 on "International Cooperation on Breeder Reactors." Those views included:

The United States should continue to develop LMFBR breeders as insurance against possible future resource depletion. For such an approach to be credible, breeders should be proven as an option through the demonstration of commercial-size units;

The United States should take steps to move back into a position of technological leadership on the breeder reactor and, particularly, on the breeder fuel cycle and nonproliferation measures;

The United States and Japan and, possibly, the United Kingdom should plan a joint breeder demonstration program, with the eventual participation, particularly of the United Kingdom being provided for, and with specific reference to reprocessing and plutonium management;

Consideration should be given to forging an international consortium or cooperative suitable for the purpose of international fissile material supply and control, with that consortium or cooperative of incorporating certain existing and planned sensitive nuclear fuel cycle facilities and include provision for future participation and supply options. Barnwell was a key factor in that latter, somewhat abstract expression. Those of us who, at that time were concerned with trying to mount into the international cooperative efforts recognized simply that, with a Barnwell retired from active participation in the international arena, that the United States had no position whatsoever to advance in terms of developing international cooperative efforts. It was clear to those of us who were looking carefully at the matter at that time that, if the United States had been able to advance a Barnwell as being available as its chip in helping to force international cooperative arrangements, there could have been significantly more substantial movement toward same than did occur.

That has to do with the difficulty of entering into international cooperative arrangements for reprocessing and plutonium management. The policies of the past administration made it impractical to pursue such arrangements, in light of the U.S. attempt to impede work by itself and others on reprocessing and, to a lesser extent, on breeders. Present difficulties should be significantly less if the United States is able to find acceptance as a credible partner in long-term U.S. Government-supported international cooperative ventures. This acceptance will relate to the character and stability of goals, funding, and institutional arrangements, all of which will present their own particular difficulties. Notwithstanding, the opportunities, costs, and benefits are probably such as to justify earnest, sophisticated approaches to structuring international cooperative efforts in these fields.

In concluding, I would summarize as follows:

Spent fuel reprocessing and recycle are not today critical to the viability of light-water reactors. Reprocessing and recycle could become so in the near term and will become so in the long term.

Fuel reprocessing capacity, such as that represented by Barnwell, which support the breeder development is necessary now and significant reprocessing capacity additions could be required in the near term to support prospective breeder commercialization.

There are significant but critical differences in reprocessing of spent fuels from LWR's and from breeder reactors.

Burner reactors do not, at this time, appear to be a realistic option in the United States.

Reprocessing needs for all scenarios of LWR and breeder reactor growth suggest the need for multiple plants of BNFP capacity. The problem today is not how many plants. It is how to get the first one in operation. I was one of those who earlier have characterized Barnwell as a solution in place waiting for the right problem to be defined so that we can use it, and this is very different from most of the situations we face today in the United States.

Further, there is no significant uncommitted inventory of plutonium for commercial nuclear power reactor research, development, demonstration, or commercialization.

Last, it is highly advisable for economic and political reasons to enter into international cooperative arrangements for reprocessing spent fuel and managing plutonium. The difficulties accrue from having abandoned the role and practice of positive leadership and, thus, having to redemonstrate the purpose, willingness, and reliability—this being the long-term commitment required of the effective collaborators.

I thank you for this opportunity to appear before you and will take whatever questions may follow.

[The prepared statement of John E Gray follows:]

Testimony Presented by
John E. Gray
International Energy Associates Limited (IEAL)
to the
Subcommittee on Energy Research and Production
of the
Committee on Science and Technology
of the
U.S. House of Representatives
March 5, 1981

Thank you, Madame Chairman. I am John E. Gray of International Energy Associates Limited of Washington, D.C. I also serve as Chairman of both the Energy Policy Committee and of the Nuclear Policy Working Group of the Atlantic Council of the United States. I am grateful for this opportunity to appear before your Committee and provide my views on certain matters, as you requested.

The particular matters on which I have been asked to comment are:

- the importance of fuel reprocessing to the viability of light water reactors and the timing requirements for reprocessing capacity to support the breeder development program as well as eventual breeder commercialization;
- the differences in reprocessing for LWR and breeder reactors and the reprocessing needs for various projected scenarios of LWR, burner and breeder reactor growth;
- the effect of these various scenarios on the inventory of available plutonium;
- the advisability of and difficulties anticipated in entering into international cooperative arrangements for reprocessing spent fuel and managing plutonium.

I will comment on these matters in the same order and then summarize my views.

The nation's energy resources are finite in extent, while future energy demand is projected to increase geometrically, albeit at a lower rate than in the past. The success of the nuclear option in meeting the electrical portion of this demand is dependent upon the efficiency with which we use our natural uranium resources. The capability to reprocess the spent nuclear fuel generated by thermal light water reactors (LWRs) is fundamental in this regard.

At the beginning of 1980 the DOE estimated the U.S. $30 forward cost reserves at 645,000 tons; actual recovery of material in this cost category may range beyond $60 per pound, more than twice the current market price. If this reserve category is adjusted for inflation in the past year, for milling losses, and for mining accessability, the producible uranium reduces to about 500,000 tons. Without reprocessing this could only support about 100 Gigawatts-electric (GWe) of LWR nuclear capacity, presuming 30 year operating lifetime for individual plants. While the development of probable potential resources, as well as higher cost category reserves and resources over the next twenty to thirty years may triple the producible amount of uranium, the supply and demand balance will become increasingly marginal as well as costly after the end of this century.

The most recent DOE forecasts of U.S. nuclear power growth are for an installed capacity of 160 to 200 GWe by the year 2000, and 290 to 460 GWe by the year 2020. There are those in the industry who believe that while these forecasts may seem to be reasonable in the light of events over the past four years, they could turn out to be on the low side. For example, 400 GWe in the year 2000 is possible and this figure could double by the year 2020; this presumes, however, that there is an adequacy of nuclear fuel. This underlines the necessity for concern with regard to the possibility of marginal supply situations and the necessity to develop efficient options.

Two major options for extending uranium resources are the implementation of uranium and plutonium recycle, and the development of the fast breeder reactor. Both of these alternatives require that spent nuclear fuel be reprocessed. While recycle could extend supportable nuclear capacity by almost 50 percent, the liquid metal fast breeder reactor (LMFBR) could extend supportable capacity by almost two orders of magnitude (10,000 percent), and allow the nuclear power option to continue indefinitely.

An additional option may be a major increase in the overall separation factor in enrichment of uranium, as in laser enrichment. However, realization of this option could extend nuclear capacity only by about 20%. It is also noted that changes in LWR fuel design and its management could extend LWR capacity by 10 to 15 percent.

The recycle of uranium and plutonium in LWRs would result in about a one-third savings in natural uranium and about a one-fifth savings in uranium enrichment requirements. Viewed another way each metric ton of reprocessed spent fuel is equivalent to mining 2.5 tons of natural uranium and performing one unit of enrichment separative work. For example, reprocessing the more than 7,000 metric tons (MT) of civilian reactor spent nuclear fuel presently accumulated in the U.S. would be equivalent to the domestic mining industry's anticipated production this year (1981).

The recycle extension obtains from the fact that current generation LWR spent fuel contains 6 to 7 kilograms of fissile plutonium per metric ton. Recycling this plutonium is a partial substitute for uranium enrichment and associated uranium feed. The recycle of uranium further reduces the demand for fresh uranium feed.

In order for recycle to be implemented it would be necessary to have operational reprocessing plants. A 1500 metric ton per year plant such as that at Barnwell would service the spent fuel of approximately 50 to 60 GWe of LWR capacity. Assuming the DOE nuclear growth forecasts discussed already, approximately four such plants could be used to capacity by the end of the 1990s. Such an array of plants would be required to work the substantial spent fuel backlog built up by then.

The DOE nuclear growth forecasts already mentioned correspond to a projected generation of about 70,000 metric tons of LWR spent fuel by the year 2000, and about 180,000 metric tons by the year 2020. This cumulative fuel discharge equates to a cumulative plutonium content of about 450 and 1200 metric tons of fissile plutonium, respectively. If reprocessed, this would allow recycle to proceed as mentioned earlier or it could instead be used to provide the substantial initial fissile plutonium required to deploy commercial breeders.

The importance of reprocessing this substantial mine of spent fuel which will be discharged by LWRs in the future may be viewed in terms of current oil import costs. The potential energy equivalent involved, assuming import costs of $35 per barrel, are 10.5 and 27 billion barrels of oil, respectively, costing $367 and $945 billion in 1981 dollars. Reprocessing for deployment of the breeder would amplify these values.

The fissile plutonium required for the deployment of LMFBRs must be obtained from the reprocessing of spent fuel generated by LWRs. The first generation breeders are projected to require 7.5 MT of fissile plutonium for start-up, first core and initial reloads, an amount contained in about 45 years of spent fuel discharged by a 1 GWe LWR plant. Viewed another way, six (6) 1 GWe LWRs will produce about one MT of fissile plutonium in one year, and 7.5 MT in 7.5 years. The fissile plutonium content of all of the LWR spent fuel projected to be discharged by the year 2020, would provide start-up inventory for about 160 GWe of first generation LMFBRs.

The excess plutonium bred annually in the early breeders is projected to be approximately 0.25 MT per GWe. This corresponds to an early breeder growth rate of approximately 3.3 percent, or close to what electricity growth rates may be in the period 2000-2020. If the breeder is to be the future nuclear option and that option is to bear a substantial share of electricity demand, then earliest possible deployment is suggested. This will allow maximum advantage to be taken of breeder and breeder reprocessing technology advances and eliminate the need for considering use of recycle for a limited period.

While the reprocessing of fuel discharged from breeders, as distinct from fuel discharged from LWRs, is not perceived as a major problem, the projected high burn-up of breeder core fuel may require modifications to LWR spent fuel reprocessing plant designs. The high burn-up and high plutonium content will impose stringent handling and transportation systems.

If plutonium recycle were to be established commercially, there could arise some incentive to increase further the plutonium loadings in some reactors, while leaving other reactors to be fueled with uranium. Some of the newer pressurized-water reactors have been designed with the flexibility of adding sufficient control absorbers so that these reactors can be fueled entirely with natural uranium and plutonium. This is the "plutonium burner" reactor. The plutonium recovered from the discharge fuel is recycled, and makeup plutonium is obtained from reprocessing discharge fuel from uranium-fueled water reactors.

The plutonium burner water reactor is adaptable to those concepts wherein it is desirable to localize the issues connected with utilization of plutonium fuel. Such a reactor could be located at a nuclear energy center, where there would also be co-located facilities for fuel reprocessing and MOX fuel fabrication. Discharged fuel from offsite uranium-fueled reactors could be shipped to such an energy center, and the plutonium recovered from this fuel could be utilized on site as fuel for the plutonium-burner reactors. For similar reasons, a utility company could find it desirable to centralize plutonium-burner reactors on some of its sites, to be fueled with make-up plutonium produced in its uranium-fueled reactors at other sites.

If plutonium recycle in water reactors were to be authorized, it is likely that the recycle plutonium would initially be utilized as a partial loading in uranium-fueled water reactors, with more interest in higher plutonium loadings developing as the plutonium recycle industry grew and matured. However, the utilization of plutonium in water reactors would probably give way to the competitive demand for this plutonium as start-up fuel for the fast breeder.

Notwithstanding the theoretical interest in this "burner" concept, it does not appear to be going anywhere, at this time.

Turning now to the effect of these scenarios on the inventory of available plutonium - it is my understanding that there are about 11 metric tons of separated plutonium available for the U.S. civilian breeder programs. It is also my understanding that this amount is substantially committed for use in the Fast Flux Test Facility (FFTF) and the Zero Plutonium Production Reactor (ZPPR). Thus, there is no substantial inventory of plutonium known to be available for commercial programs, or for any of the scenarios earlier referred to.

Regarding the advisability of entering into international cooperative arrangements for reprocessing spent fuel and managing plutonium, I have earlier expressed relevant views before this Committee. They are found in the Rockefeller Foundation report of 1978 on "International Cooperation on Breeder Reactors", prepared by my associates and I. These views follow:

"The U.S. should continue to develop (LMFBR) breeders as insurance against possible future resource depletion. For such an approach to be credible, breeders should be proven as an option through the demonstration of commercial-size units....

"The U.S. should take steps to move back into a position of technological leadership on the breeder reactor and particularly on the breeder fuel cycle and nonproliferations measures....

"The U.S. government should recognize that continued international exchange and cooperation on R&D, demonstration, and safety and licensing may make nonproliferation-related agreements easier to achieve.

"The U.S. and Japan - and possibly the U.K. - should plan a joint breeder demonstration program. Eventual participation of additional countries, particularly the U.K., should be provided for. The continental European breeder program is already closely integrated, and no specific recommendation is made in this regard. However, the U.S. and others should recognize that that group is open to additional interchanges, particularly on a commercial basis.

"The U.S. and Japan - and possibly the U.K., the F.R.G., France and the U.S.S.R. - should form a working group, possibly under IAEA auspices, among their respective licensing agencies which would explore the merit of increased cooperation in developing breeder licensing standards and procedures.

"Consideration should be given to forging an industrial consortium or cooperative suitable for the purpose of international fissile material supply and control. The consortium or cooperative could incorporate certain existing and planned sensitive nuclear fuel cycle facilities and include provision for future participation and supply options. In this context a feasibility study should be undertaken of an international fuel cycle authority responsible for the control of fissile material. The analysis should be detailed and specific beyond the broad conceptual work already done on this topic by the IAEA and other organizations.

"Finally, an understanding and resolution of the nonproliferation issue as it relates to the LMFBR fuel cycle should be sought by forming an international working group organized through INFCE or otherwise independently by the U.S., the F.R.G., France, the U.K., the U.S.S.R. and Japan."

Regarding the difficulty of entering into international cooperative arrangements for reprocessing and plutonium management, the policies of the past administration made it impractical to pursue arrangements, in light of the U.S. attempt to impede work by itself and others on reprocessing and to a lesser extent on breeders. Present difficulties should be significantly less, if the U.S. is able to find acceptance as a credible partner in long-term U.S. Government-supported international cooperative ventures. This acceptance will relate to the character and stability of goals, funding and institutional arrangements, all of which will present their own particular difficulties. Notwithstanding, the opportunities, costs and benefits are probably such as to justify earnest, sophisticated approaches to structuring international cooperative efforts in these fields.

In concluding I would like to summarize my views on the foregoing:

- Spent fuel reprocessing is not today critical to the viability of light water reactors. It could become so in the near term and will become so in the long term.

- Fuel reprocessing capacity (such as that represented by BNFP) to support the breeder development is necessary now and significant reprocessing capacity additions could be required in the near term to support prospective breeder commercialization.

- There are significant but not critical differences in reprocessing of spent fuels from LWRs and from breeder reactors.

- Burner reactors don't, at this time, appear to be a realistic option in the U.S.

- Reprocessing needs for all scenarios of LWR and breeder reactor growth suggest the need for multiple plants of BNFP capacity. The problem is not how many plants. It is how to get the first one in operation.

- There is no significant uncommitted inventory of plutonium for commercial nuclear power reactor research, development, demonstration or commercialization.

- It is highly advisable for economic and political reasons to enter into international cooperative arrangements for reprocessing spent fuel and managing plutonium. The difficulties accrue from having abandoned the role and practice of positive leadership, and thus having to re-demonstrate the purpose, willingness, and reliability - the long-term commitment required of effective collaborators.

Thank you for this opportunity to appear before you.

Mrs. **Bouquard.** Thank you very much for your excellent testimony.

Our next witness is Dr. James Colby. Dr. Colby, we have your written testimony before us. You may summarize your remarks. You may proceed as you wish.

## STATEMENT OF L. JAMES COLBY, JR., SENIOR VICE PRESIDENT, ALLIED CHEMICAL CORP., ACCOMPANIED BY JAMES A. BUCKHAM, EXECUTIVE VICE PRESIDENT, ALLIED-GENERAL NUCLEAR SERVICES

Dr. **Colby.** Thank you, Madam Chairman.

We also in the statement attached provide answers to the six written questions we received from the subcommittee. I hope they will also be entered into the record.

I am accompanied here today by Dr. James A. Buckham, executive vice president of Allied-General Nuclear Services. We hope, in the question period, we will be in a position to answer any questions that the committee may have concerning our facility or our views with regard to the reprocessing area.

I will summarize very briefly and then we can get a chance to get on to the questions.

As you know, in early 1977 President Carter attempted to put a stop to the plutonium economy. This took the form of the policy to stop the breeder program through the termination of the Clinch River breeder, which of course the committee and others on the Hill did not allow. It also ended up in an indefinite deferral of commercial reprocessing and a major change in the direction that the United States was taking with regard to closing the back end of the fuel cycle.

Notwithstanding this decision on the part of the President at that time, Congress has appropriated funds to keep the option of the Barnwell facility alive. This has occurred through several fiscal years. We are currently in fiscal year 1981 and accomplishing the programs for the benefit of the country.

Madam Chairman, this subcommittee has played a very important role in seeing to it that the option that we have at Barnwell, as well the other plutonium-based programs in the country, are still alive and open for us to consider what we will do in the future.

What exists at Barnwell today is the largest, modern spent-fuel reprocessing facility in the world. It has not been used. The facilities there are often characterized as being only partially completed and are, in fact, not complete. The separations facility is finished. The UF-6 facility is finished. We have a safeguards program that is in operation—probably, the best safeguards program that exists in the world. It has been built on the basis of operation—from an operational standpoint. We have storage facilities there not only for spent fuel, but for waste, for uranium product, and for plutonium product.

It is often overlooked that a plant in the present condition of Barnwell presently constitutes, in its completeness, the same thing that exists at presently operating reprocessing plants around the world. This includes neighboring plants, such as at Savannah River, which has been operating safely and successfully for over 25 years.

My written statement reviews the results of the R. & D. program that we have completed to date, and it also proposes what a program for fiscal year 1982 should contain. The proposed activities are unique in that the results can only be obtained utilizing the Barnwell plant and staff. These programs are geared differently now toward moving the Barnwell plant closer to reprocessing as a reprocessing facility, as opposed to the prior programs and the current one in existence for fiscal year 1981. The present program is for safeguards and spent-fuel storage, primarily.

To maintain those facilities that we have at Barnwell and the staff, it costs about $18 million a year. For the past 2 years, we have received $11.5 million through a program that we have presented to this subcommittee and others here on the Hill and have received approval. The additional funds have come about by performing programs for others, such as Oak Ridge National Laboratory and the like, but the spending rate has been at about the $18 million level per year.

For fiscal year 1982, we have proposed through the Department of Energy that we undertake several additional activities to strengthen our operating facility and move it closer to a reprocessing capability.

I believe it is essential, as we have heard from our prior speakers, that a plutonium resource for our breeder program will be mandatory not only for our Clinch River breeder but, also, subsequent demonstration breeders.

It is also mandatory that, if we do embark or choose the decision in the future to deploy breeders, we will have to have an operating reprocessing facility, mining the spent fuel for the plutonium to fill the pipelines to create the breeders that we need the energy from.

It is also true as was mentioned that recycle of breeder fuel back to the reactor is also important or you do not have a breeder.

The Barnwell plant in my view, and I believe in others, is considered a national asset at its present point in time. I think some of the reasons have been very eloquently expressed prior to this paper by Dr. Starr, as well as John Gray.

The plutonium breeder, as we understand it for Clinch River, will require plutonium, and this plutonium will need to be recovered from existing LWR spent fuel. It does not mean that we have available to us an infinite supply of plutonium from our weapons program that we can tap to fill, not only the FFTF, but the breeders as we move forward.

It is my understanding that the weapons program is actually in deficit and that new plutonium production reactors are being considered. There is another reason—the plutonium for breeders requires a certain isotopic composition to be typical and, therefore, demonstrate what type of plutonium and what type of reactor physics are involved for these plants. That type of plutonium does not come from a weapons type of operation.

It is essential that reprocessing of the LWR spent fuel get underway several years before the first demonstration breeders are built; and, I believe at least 10 years in advance, reprocessing must occur before one makes the decision for deployment of breeder reactors.

Together reprocessing and breeders can extend our probable uranium reserves for thousands of years instead of just tens of years without them.

Reprocessing also provides, in our view, many significant benefits to the management of radioactive wastes. Reprocessing places the high-level wastes in a chemically stable form with a sevenfold volume reduction over storing spent fuel. Also, because of the removal of most of the plutonium, the high-level waste from reprocessing will have a lower hazard level throughout their lifetime than does spent fuel. For example, reprocessing wastes decay to a hazard level equivalent to the original ore in only about 500 years, whereas, spent fuel decays to that same hazard level of the original ore in 10,000 years.

Madam Chairman, we have been asked to comment on the maintainability and operability of Barnwell. We do have an extensive discussion of this subject in our written statement, and I would at this point only make a few comments concerning this.

Barnwell has been operated extensively on cold uranium for the past 4 years. These tests show that the plant is capable of exceeding its daily design capacity of 5 tons per day. In fact, we believe it can operate at 6½ tons per day with ease.

Its operability and maintainability have been unanimously endorsed by a team of independent experts sponsored by the utilities through the Electric Power Research Institute. They have come in and looked at our designs. They have made some comments concerning them—constructive—but, on balance, we believe that we have an excellent plant.

It is interesting to note that all plants built outside of the United States use the philosophy of the Barnwell plant with regard to its maintenance approach. We have a remote maintenance facility. All aspects of the facility, however, are not remote maintenance because they do not require maintenance in certain areas of the plant.

If there are questions later on, we can get into the detail on that if that is a specific interest to individuals on your committee.

Whatever Barnwell's future role, it seems clear that Federal ownership is an essential prerequisite to the further development of Barnwell.

Construction of Barnwell as the Nation's first large reprocessing plant was encouraged by the Federal Government as an essential part of nuclear power. However, President Carter's decision signaled the end to prospects of a viable role for private investment in reprocessing. That decision and events since then demonstrate a uniqueness to this segment of the nuclear industry which has become increasingly apparent to all concerned.

Reprocessing is somewhat similar to enrichment and heavy water in their areas of technology. They generally are the province of individual governments.

These policies which have been subject to change, relative to the Congress and other administrations, create unacceptable risks for private enterprise to enter the reprocessing ventures at this time.

Also, it is not surprising that foreign reprocessing plants, also enrichment plants, and heavy-water plants, are owned by Government authorities.

We, therefore conclude that Federal ownership of Barnwell is essential. To the extent Barnwell is to be used for services to the industry, such as reprocessing, spent-fuel storage, or the like, appropriate fees could be charged to help alleviate the cash flow and costs associated therefrom.

To conclude, Madam Chairman, if Barnwell were to be used for reprocessing, as Secretary Edwards is recommending, it could not become operational on a sustained basis before 1987 and possibly later. As outlined in this statement, any delay in this date would have a serious and possible crippling effect on current planning for the breeder reactor demonstration program.

The owners of Barnwell believe that final decisions about the future of Barnwell should and can be made this year. If decisions are not made in a timely fashion, the most likely result is that the Barnwell facility will be closed, the talented staff will be dispersed, and the significant national asset that it represents would be wasted. This action would, we believe, foreclose a number of options that are critical to the future of nuclear energy in the United States.

We hope that the subcommittee will support a DOE request for operating funds for Barnwell for fiscal year 1982, and we hope the committee will view with alarm the absence of such requests for funds in the Department of Energy's budget.

Madam Chairman, this concludes our statement. We would be most pleased to answer any of your questions.

[The prepared statement of Dr. Colby follows:]

# STATEMENT SUBMITTED TO
# THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
# OF THE
# SCIENCE AND TECHNOLOGY COMMITTEE
# U.S. HOUSE OF REPRESENTATIVES

ON

# THE FUTURE ROLE OF THE
# BARNWELL NUCLEAR FUEL PLANT

MARCH 5, 1981

BY

L. JAMES COLBY, JR.
SENIOR VICE PRESIDENT
ALLIED CHEMICAL CORPORATION
AND
JAMES A. BUCKHAM
EXECUTIVE VICE PRESIDENT
ALLIED-GENERAL NUCLEAR SERVICES

Madame Chairman and Subcommittee members, my name is L. J. Colby, Jr. I am a Senior Vice President for Technology with Allied Chemical Corporation. Allied Chemical, through Allied Chemical Nuclear Products, Inc., is a 50 percent owner of the Barnwell Nuclear Fuel Plant (BNFP) in South Carolina. The General Atomic Company, through its partnership in Allied-General Nuclear Services (AGNS), owns the remaining 50 percent of the Barnwell Plant. I am accompanied by Dr. James A. Buckham, Executive Vice President of Allied-General Nuclear Services.

The Subcommittee has requested written answers to six questions. Those questions and answers are attached to this statement.

## STATUS OF BARNWELL NUCLEAR FUEL PLANT

In April, 1977 President Carter decided to defer indefinitely commercial reprocessing, the purpose for which the BNFP was originally designed and built. Notwithstanding this decision Congress has appropriated funds for research and development programs at the BNFP for the fiscal years 1978 through 1981. This Subcommittee has played an important leadership role in providing this funding. The R&D funds voted by Congress have: (1) produced valuable research results, (2) preserved the nucleus of a unique technical staff at Barnwell, and (3) maintained the option of using the Barnwell facility for a number of purposes in the future.

What exists at Barnwell today is the largest modern spent fuel reprocessing facility in the world. The spent fuel pool is completed and can be available for storage with the installation of new racks, a security system, and other minor modifications. Storage tanks for liquid wastes and plutonium are also available which would allow the chemical separations facility to operate for up to 18 months on high burnup Light Water Reactor (LWR) fuel and considerably longer with other fuels. It is often over-looked that the plant as presently constituted is capable of performing the same reprocessing functions as are currently in operation at all the foreign and U.S. Government reprocessing plants, including the neighboring Savannah River Plant, which has operated successfully and safely for over 25 years.

To operate the BNFP on a sustained basis in the originally intended mode will require the construction of plutonium and waste solidification facilities at the Barnwell site. We estimate that these additional facilities could cost as much as $500-750 million.

This statement reviews the results of the R&D program to date and the proposed activities that can be undertaken at Barnwell in FY'82. These proposed FY'82 R&D activities are geared toward moving the Barnwell Plant closer to ultimate use as a reprocessing facility.

In addition, this statement reviews several other potential uses for the Barnwell Plant, addresses why we believe that BNFP cannot be operated commercially, and answers charges by some that BNFP cannot operate on a reliable basis.

## RESULTS FROM BARNWELL R & D PROGRAM AND PROPOSED FY'82 ACTIVITIES

From FY'78-FY'81, the Federal Government through the Department of Energy has conducted various research and development activities at the BNFP. Several benefits have resulted from those programs.

In the area of nuclear safeguards, the AGNS staff has developed what many believe to be the most sophisticated nuclear safeguards system in the world. That system is being used for safeguards training under provisions of the Nuclear Non-Proliferation Act of 1978. Barnwell can continue to be a valuable training center and testing system for future advanced safeguards hardware.

In the area of proliferation-resistant fuel cycles, the AGNS staff has studied several proliferation-resistant nuclear fuel cycles. Out of these studies have come recommendations that involve possible treating or "spiking" plutonium to make it more proliferation-proof and blending plutonium with uranium to make its diversion for weapons use more unattractive.

In the area of spent fuel transportation and storage, studies conducted at Barnwell will result in improved techniques for transporting, handling and storing spent nuclear fuel.

To maintain the existing facilities and staff at Barnwell requires approximately $18 million per year. This level of funding has been achieved for FY'80 and FY'81 by two mechanisms. First, Congress has provided a line item of $11.5 million in the Department of Energy (DOE) budget for a base R&D program at Barnwell for each year. Second, funding outside the base program has been sought out and secured at a level of $6-7 million for each fiscal year. This funding has come largely through contracts with the Department and its contractors in areas primarily dealing with spent fuel transportation and storage and nuclear safeguards development and training.

For FY'82, we have proposed that the Department undertake several program activities at Barnwell which would strengthen the option of using the facility for a number of purposes, including reprocessing of spent nuclear fuel as a prerequisite to the operation of demonstrational reactors in the U.S. Breeder Reactor Program.

We have proposed to the Department that some FY'82 funds be directed toward an engineering evaluation of the additional facilities required for sustained operation of Barnwell. Processes and equipment for these additional facilities would be selected based on the current state of the technology and generic conceptual designs. Testing would be conducted on the separations facility to incorporate desirable refinements, and maintenance programs would be continued to assure future operational readiness.

Spent nuclear fuel cask and handling studies should also be performed in FY'82 to prepare for eventual receipt of spent fuel at Barnwell. Advanced spent fuel cask designs would be studied, and, to the extent feasible, would be evaluated under simulated conditions. Specific problems relating to classifying and handling failed and damaged fuel would also be studied and reported. Preparation would be made for timely utilization of the Barnwell Plant's spent fuel storage pool as a necessary prerequisite to reprocessing.

Additional studies which can be performed at Barnwell in FY'82 are in the areas of commercial nuclear waste management and nuclear materials security and safeguards.

In commercial nuclear waste management, waste which has been separated by reprocessing spent fuel is the best form for permanent disposal. Conceptual designs are necessary to accomplish this and to coordinate waste activities at a reprocessing facility with the operation of the final repository. Emphasis would be given to vitrified waste in conventional containers, but consideration would also be given to non-standard waste forms from reprocessing such as disposal of defective vitrification furnaces and other equipment which cannot be decontaminated. Consideration would also be given to any other reprocessing wastes that are not amenable to near-surface burial, particularly those that may be excessively contaminated with transuranic elements. Cost-benefit analyses would be performed utilizing the AGNS Waste Management Economics Model.

Some safeguards and security activities should be continued at Barnwell to permit future utilization of the sophisticated safeguards systems that have been developed there.

During the recently completed International Nuclear Fuel Cycle Evaluation (INFCE), use of advanced safeguards was identified as the principal means of improving the non-proliferation aspect of LWR fuel reprocessing. Extension of the research and development efforts conducted at BNFP during the past four years is essential to assure effective safeguards at reprocessing facilities in the future both in the United States and abroad. Specific additional studies include installation and testing of physical protection alarm systems and initial procurement and testing of computerized information systems. Computer security can be improved by controlling access to terminals and operational software. Additional training would be provided for security personnel and canine teams. The intrusion detection test zone would also be expanded to provide more realistic testing and training. Additional improvements would be made to the accountancy system and demonstrated in a plant-wide test to approach the International Atomic Energy Agency (IAEA) diversion detection objectives. On-line instrumentation development would be continued and evaluated to improve accuracy of the accountancy system, and backup capabilities to improve reliability would be provided. Plans would also be developed and demonstrated for a possible IAEA inspection system at BNFP.

## POTENTIAL USES FOR THE BARNWELL NUCLEAR FUEL PLANT

Potential uses for the Barnwell Plant include the following:

### Plutonium to Supply the U.S. Breeder Reactor Program

Implementation of a breeder reactor program in the United States for production of electric energy will require large quantities of plutonium. We understand that present DOE planning has the Clinch River Breeder Reactor (CRBR) coming on line about 1990 and that construction of a larger breeder reactors is being considered for operation in the 1990s. Reprocessing of LWR spent fuel at Barnwell beginning in 1987 is essential to satisfy plutonium feed requirements for this program.

### Breeder Fuel Reprocessing

An evaluation has been performed by the Oak Ridge National Laboratory (ORNL) and AGNS on utilization of the

BNFP in support of the U.S. Breeder Reactor Reprocessing Program. The basic analyses in this evaluation are completed, and the report is being reviewed in preparation for publication. This evaluation showed that it is not technically feasible to reprocess breeder fuel in the existing BNFP if its capability for reprocessing LWR fuels is preserved. However, the evaluation showed that many of the BNFP facilities could be used in conjunction with a new facility at Barnwell for processing breeder fuels. The BNFP facilities that could be jointly utilized include fuel and waste storage, plutonium conversion, waste treatment, and some solvent extraction, solvent recovery, and acid recovery systems. This ORNL-AGNS evaluation concluded that the location of a breeder reprocessing capability at Barnwell could result in cost savings to the U.S. government in the order of $500 million as compared to building it at another location.

## Safeguards Research and Development and Training

The International Nuclear Fuel Cycle Evaluation stated that future chemical reprocessing throughout the world should incorporate additional safeguards measures. During the past three years, AGNS has been developing for the Department of Energy the world's most advanced system for safeguarding fuel cycle facilities, particularly nuclear fuel reprocessing plants.

The development program has included work on physical protection, containment, surveillance, and material accountancy. Each of those aspects has been coordinated with the others to assure the development of a soundly integrated system. However, to show the usefulness and integrated operability of an advanced system, additional studies should be continued and systems demonstrated. The BNFP as it exists today represents a unique and ideal testing area for such a program.

Along with the continuation of safeguards development and demonstration activities, training in safeguards technology (including on-the-job training during testing exercises), could be conducted at BNFP. These training programs could include courses in all areas of safeguards -- physical protection, containment, surveillance, and accountancy. Field training programs could be included in all these areas. Such courses could be given to U.S. technicians, as well as those from abroad, and would be particularly well suited to IAEA inspectors -- an activity to which the United States is committed by the Nuclear Non-Proliferation Act of 1978.

## Fuel Cycle Research and Development

Since the BNFP is not radiologically contaminated, it provides an ideal test bed for a large number of studies in the fuel cycle area. The facility is particularly well suited to test advanced ideas on proliferation-resistant modifications to the Purex process in a full-scale manner.

Continuation of such studies is appropriate so that the United States will have a leadership position in emphasizing proliferation-resistance in activities throughout the world. Such activities at BNFP would also serve to develop institutional arrangements necessary for development of regional fuel cycle centers as suggested by the findings of the INFCE.

## Fuel Disassembly and Encapsulation

Should delays develop in reprocessing LWR fuel for the U.S. Breeder Reactor Program, or should it become desirable to dispose of some spent fuel as waste without reprocessing, the BNFP is suitable for disassembly and encapsulation of spent LWR fuel. This capability has been demonstrated during special studies conducted for DOE the past two years at Barnwell, and its implementation would require only a modest capital investment in special equipment.

## Backup for Defense Fuel Reprocessing

A number of studies performed during the past few years show that the BNFP is capable of processing many of the fuels currently processed in facilities owned by the government. Therefore, the BNFP represents an ideal backup facility for the military production program should it be needed.

A collaborative study was performed in 1978 by DuPont and AGNS which showed that the BNFP is technically capable of processing several of the major fuel loads handled at the Savannah River Plant.

Similarly, a scoping study was completed by AGNS in 1980 which indicated the feasibility of processing all or part of the Hanford N-reactor spent fuel at Barnwell. That fuel is now scheduled for reprocessing in the PUREX plant at Hanford, which is currently in a standby condition. Should planned startup of the Purex plant be either delayed or prevented, the BNFP could perform this important function.

### Interim Regional Storage of Spent Nuclear Fuel

During the last Congress, attention was focused primarily on the possible use of Barnwell for away-from-reactor (AFR) storage. According to recent DOE estimates, AFR storage capacity will initially be required by 1986, and 6480 tons of such capacity are estimated to be needed by 1995.

Because essential decisions have not been made, and because of lead times involved, the goal of having AFR storage on line by 1986 is already jeopardized. There is general agreement that it would take at least nine years to design, construct, and license a new AFR facility. With respect to existing facilities, like Barnwell and Morris, decisions must be made this year if they are to be on line for regional interim storage in the 1986-1990 period.

## BENEFITS OF SPENT FUEL REPROCESSING

Secretary of Energy Edwards has stated that the Administration is considering ending the current deferral of reprocessing of commercial spent nuclear fuel in the U.S.

Such a move would help restore U.S. leadership in world nuclear matters, including non-proliferation concerns, and would also help the U.S. conserve its future energy resources. The several significant advantages of reprocessing are summarized below.

In the near term, it is necessary that reprocessing of LWR spent fuel be implemented several years before the first demonstration breeders are built in order to provide test and startup fuel assemblies. In the long term, reprocessing of breeder reactor spent fuels will be essential to recover the valuable plutonium that is generated. Together, reprocessing and breeders can extend our probable uranium reserves to thousands of years compared to tens of years without them.

Reprocessing would also permit any plutonium in excess of the needs of the breeder program to be utilized in the existing types of LWR's. Approximate savings through recycle to LWR's are: ore requirements, 35%; enrichment requirements, 23%; and $UF_6$ conversion requirements, 16%. The energy made available through recycle for each reprocessing plant the size of BNFP can be used to generate the same amount of electrical energy as would come from burning one million barrels of oil per day.

Finally, reprocessing provides many significant benefits to the management of radioactive wastes. Reprocessing places the high-level wastes in a chemically stable form (such as glass), with a seven-fold volume reduction over storing spent fuel. Also, because of the removal of most of the plutonium, the high-level wastes from reprocessing will have a lower hazard level throughout their lifetime than does spent fuel. For example, reprocessed wastes decay to the hazard level of the original ore in 500 years as compared to 10,000 years for spent fuel.

The low-level waste picture is also improved, primarily through significant reductions in mill-tailings. For the long-term, reprocessing would enable continued future improvements in waste management practices and would permit recovery of some valuable non-radioactive materials. An example of the latter is the platinum family of metals which are rare in nature but abundant in fission products. These are being used increasingly for such purposes as catalytic converters on automobiles and are obtained largely today in the U.S. by imports from the Soviet Union and South Africa.

## ADEQUACY OF THE BARNWELL TECHNOLOGY

Madame Chairman, we want to address directly questions which have been raised about the operability of the BNFP and the plant's ability to operate reliably.

The BNFP was constructed during the period 1971-75 as the first large-scale U.S. plant for reprocessing commercial spent nuclear fuel. The facility embodies the time-proven

Purex process, which was first used in U.S. defense plants in mid-1950's and has subsequently been used in virtually all reprocessing plants throughout the world. Plants currently being designed for overseas use will again use the Purex process. Thus, although completed six years ago, the BNFP clearly employs the best available process technology.

No basic improvements in Purex reprocessing technology have recently been made or can be expected with this mature technology. However, the International Nuclear Fuel Cycle Evaluation and related U.S. studies have demonstated the need for advanced safeguards systems in future reprocessing and othe fuel cycle plants. This is to make possible their protection and international surveillance to detect any attempted diversion of special nuclear material. For the past four years, the staff at BNFP has been developing under contract to DOE what many acclaim as the most sophisticated safeguards system in the world. This system, embodying modern accountancy, surveillance, and physical protection devices, is ready for installation at BNFP. It would make the Barnwell Plant the only truly up-to-date plant in the world -- one capable of alleviating concerns about proliferation of weapons materials. Moreover, testing has shown that the use of such a sophisticated safeguards system would provide the latest and best process control and monitoring instrumentation, thus giving benefits in improved operability and safety of reprocessing.

The BNFP has been extensively tested with non-radioactive chemicals. These tests show that the Plant is capable of exceeding its daily design throughput rate of 5 tons/day of uranium. Its operability and maintainability has been unanimously endorsed by an electric utility team of independent experts sponsored through the Electric Power Research Institute (EPRI). However, they recommended a follow on evaluation to review the desirability of relocating specific pieces of equipment or providing remote replacement capabilities in areas where it seems desirable in light of more recent experience. The plant employs a combined maintenance concept, utilizing remote maintenance and replacement techniques where experience indicates a need for any maintenance. For equipment such as pipes and tanks with no prior history of maintenance requirements, the more economical contact maintenance provisions have been made. This combined maintenance concept, widely endorsed and used overseas, offers the possibility of improved in-service time at reasonable cost.

Thus, through the use of proven technology and improved maintenance practices and with the availability of advanced safeguards systems, the BNFP represents modern technology that is capable of reliably meeting future U.S. government reprocessing needs.

## THE NEED FOR FEDERAL OWNERSHIP OF BARNWELL

Whatever Barnwell's future role, it seems clear that Federal ownership is an essential prerequisite to further development of Barnwell. The necessity for government ownership is not hard to explain.

It is worth recalling that until the mid-1970s, the reprocessing of spent nuclear fuel to recover the fuel value of the residual uranium and plutonium for recycle was accepted as an essential element in the development of nuclear power in the United States. The construction of Barnwell as the nation's first large-scale reprocessing plant was approved by the Atomic Energy Commission in an environment that accepted commercial reprocessing as an integral part of nuclear power.

However, President Carter's 1977 decision to defer commercial reprocessing of spent fuel and the recycling of plutonium in the United States signalled the end to prospects of a viable role for private investment in these sectors of the nuclear fuel cycle. That decision and events since then demonstrate a uniqueness to this segment of the industry which has become increasingly apparent to all concerned. Policies which have been subject to change every Congress and every Administration create unacceptable risks for private participation in reprocessing ventures.

It is not surprising, therefore, that foreign reprocessing plants are owned by government authorities. With enactment of the 1978 Nuclear Non-Proliferation Act, the U.S. government has already assumed greater control over reprocessing and this trend will doubtless continue.

Similarly, government concerns and decisions have come to dominate the field of AFR storage. The storage of spent fuel in an AFR is an interim stage in the management of the nuclear fuel cycle. It is clearly a temporary step, until policies and programs with respect to long-term storage are determined. The duration and extent of AFR needs depend entirely on the policies and programs of the Federal government.

Although we conclude that Federal ownership of Barnwell is essential, it does not follow that the costs of developing and operating Barnwell would be borne solely by the Federal government. To the extent that Barnwell is to be used for services to the nuclear industry like reprocessing and spent fuel storage, appropriate fees would be charged to utilities to underwrite the cost of these services.

## CONCLUSIONS

If Barnwell were to be used for reprocessing, as Secretary Edwards is recommending, it would not be expected to be available on a sustained basis before 1987 and possibly later. As outlined in this statement, any delay in this date would have a serious and possibly crippling effect on current planning for the breeder reactor demonstration program.

The owners of Barnwell remain convinced that the facility is a major national asset which should be acquired by the Federal government as soon as possible. If Barnwell is to be used for reprocessing under government ownership, we are ready to work with Congress and the Administration to allow the transfer of Barnwell to take place as expeditiously as possible.

While we welcome your support for the talented staff and R&D programs at Barnwell, the owners are not willing to continue this program indefinitely. We believe that final decisions about the future of Barnwell must be made this year. If decisions are not made in a timely fashion, the most likely result is that the Barnwell facility will be closed and the talented staff will be dispersed. This action, would, we believe, foreclose a number of options that are critical to the future of nuclear energy in the United States.

Madame Chairman, this concludes my statement. Dr. Buckham and I would be pleased to answer any questions that the Subcommittee might have.

## QUESTIONS FROM SUBCOMMITTEE

1.) QUESTION:

What viable method of operating Barnwell as a reprocessing facility results in the least cost to the government?

ANSWER:

The least cost to the Federal Government could be achieved by a system of fees from utilities which would cover acquisition and operating costs and thus minimize direct Federal Government investment in Barnwell. Acquisition and operating fees could be obtained from utilities as the government acquired title to spent fuel for storage and reprocessing or disposal. Such fees for the 1750 tons that could be stored in a reracked BNFP fuel storage pool prior to reprocessing would exceed $600 million, according to an October, 1980 DOE report entitled "Department of Energy Report on Fee for Spent Nuclear Fuel Storage and Disposal Services." At full operating capacity of 1500 tons per year, the utility fees would exceed $500 million per year, which is adequate to pay back the costs of constructing the balance-of-plant facilities at BNFP within a few years as well as to cover terminal waste disposal costs.

2.) Under what conditions could the Barnwell facility be operated as a commercial venture of Allied-General Nuclear Services?

ANSWER:

As our testimony makes clear, there are no foreseeable conditions under which the owners of Barnwell would operate the facility on a commercial basis. Our testimony has covered in detail our reasons for believing that only the Government can assume responsibility for reprocessing in the United States in the foreseeable future.

3.) QUESTION:

Why does Allied-General not pursue the licensing of commercial AFR storage at Barnwell?

ANSWER:

Many of the same factors which preclude private ownership of reprocessing facilities also apply to private ownership of AFR storage facilities. In this area the uncertainty of Government policy and licensing requirements combine to make Government ownership a necessity. Private ownership is particularly unlikely because AFR storage is only one step in the management of spent fuel and nuclear waste, for which comprehensive policies and program have yet to be determined. This adds more uncertainty and further undermines the economics of private ownership of AFR storage facilities.

4.) QUESTION:

If Barnwell becomes an operating reprocessing facility, what portion of the current R&D programs at Barnwell should be continued and where should it be done?

ANSWER:

If Barnwell becomes an operating reprocessing facility, the staff now at Barnwell would be increasingly dedicated to operating the facility. During the pre-operational period, the R & D programs would become increasingly oriented to preparing the facility for operation. After the facility becomes operational, direct operating functions would be the dominant activity, although some R & D activities would still be desirable.

5.) QUESTION:

If Barnwell were to be purchased by the Government what need would there be for continued funding of the Barnwell staff?

ANSWER:

If Barnwell were purchased by the Government, there would be a need for an operating staff, working under contract to the Department of Energy, to prepare Barnwell for operational status. The staff now at Barnwell could form the nucleus of such an operational group, and could be hired or retained by whatever organization is selected as contractor for the BNFP.

6.) QUESTION:

On what basis can the Congress have confidence that the Barnwell facility would be economic to modify and operate as a reprocessing facility?

In particular, respond to the criticism from some domestic and foreign sources that the facility is not designed to permit access to equipment for repair and, as a result, costly and extended shutdowns for repairs will be a continuing problem.

ANSWER:

Our statement addresses the criticism that the facility is not designed to permit access to equipment for repair. This criticism appears to be based on a misunderstanding of the design basis for the BNFP. To repeat this basis, all equipment with an expected need for any maintenance, as determined from past U.S. and foreign reprocessing plant performance, has been located where remote maintenance or replacement can be performed. For equipment such as pipes and tanks with no prior history of maintenance requirements, the more economical contact maintenance provisions have been made.

DR. L. JAMES COLBY, JR.

Dr. L. James Colby, Jr., Senior Vice President for Technology of Allied Chemical Corporation, joined Allied Chemical in May 1975 as Executive Vice President of Allied Chemical Nuclear Products. For the previous six years, he had been associated with General Atomic Company, San Diego, California. The two companies are equal partners in Allied-General Nuclear Services (AGNS) which has constructed a nuclear fuel reprocessing facility in Barnwell, South Carolina. Dr. Colby was appointed President of Allied's Nuclear Services Division in 1976, and in addition to his responsibilities for Allied Chemical's uranium conversion installation in Metropolis, Illinois, Dr. Colby supervised the Idaho Chemical Programs managed by Allied Chemical for the Energy Research and Development Administration (ERDA) of the Federal Government. Effective September 1, 1977, Dr. Colby was appointed Group Vice President of Allied Chemical with responsibility for Corporate Research and Development and Allied's Medical Affairs Department. He was appointed Senior Vice President in October of 1979.

At General Atomic he was Director, Uranium and Light Water Fuels Division, and also served as a member of the AGNS Partnership Committee. Dr. Colby is presently co-chairman of this Partnership Committee. Previously, he had been Manager, Chemical Engineering Department, High Temperature Gas Cooled Reactor (HTGR).

Earlier in his career, Dr. Collby was Staff Physical Chemist in the Division of Reactor Development and Technology of the Atomic Energy Commission. He was responsible for fuel recycle programs, sodium technology, and reactor coolant chemistry.

In addition, he held research-oriented positions with Atomics International and the Kellogg Company.

In 1955, Dr. Colby was graduated from the University of California with a B.S. degree in chemistry. He received a Doctorate Degree in inorganic and nuclear chemistry from Purdue University in 1960, and served the same institution as an assistant professor of chemistry.

Dr. Colby is a member of the Executive Committee and Board of Directors of the American Nuclear Energy Council and a member of the Board of Directors of the Atomic Industrial Forum. He is also a member of the Oak Ridge National Laboratory Advisory Committee.

## J. A. BUCKHAM

Dr. James A. Buckham is Executive Vice President of Allied-General Nuclear Services. He obtained his Ph.D. in Chemical Engineering from the University of Washington in 1953, preceded by an M.S. degree in 1948 and a B.S. degree in 1945 from the same institution.

As Executive Vice President of AGNS, Dr. Buckham is responsible for executive direction of all technical work, AGNS in-house projects, DOE/NRC-sponsored study projects, Barnwell Plant operations, spent fuel transportation, waste management, and quality assurance/quality control.

Dr. Buckham has been a leading figure in the development of nuclear reactor technology, the reprocessing of irradiated nuclear fuels, and the management of nuclear wastes. He is probably best known for his R&D work on the application of fluidized bed technology to the solidification of high-level radioactive waste and for the development and operation of several new dissolution processes for irradiated reactor fuel elements.

Prior to joining AGNS in 1976, he was Assistant General Manager of DOE's Idaho Chemical Processing Plant for Allied Chemical Corporation. In this capacity, he directed operation of the Idaho Chemical Processing Plant, development of reprocessing methods for new HTGR, rocket and Navy fuels, operation of the Waste Calcining Facility and development of advanced designs of waste management facilities, operation of the Krypton Recovery Plant and development of advanced recovery concepts, and operation of laboratories serving all contractors at the National Reactor Testing Station.

From 1961-1971, Dr. Buckham undertook projects including large-scale demonstration of pot calcination, chop-leach processing of nuclear fuel, and Darex processing for stainless steel-containing fuels. In addition, he supervised engineering development work in fuel processing and waste disposal; reprocessing methods for nuclear fuels; and treatment of radioactive wastes, nuclear reactor decontamination and other chemical technology functions in the nuclear field.

Between 1953 and 1961, he was a member of a team engaged in the development of a process for continuous dissolution of nuclear fuels, supervised the planning and conducting of pilot plant studies of continuous dissolution and solvent extraction phases of nuclear processing, was coordinator for the Fuel Element Cutting Facility Project at ICPP, and supervised experiments on various aspects of nuclear fuel processing and fluidized bed calcination of radioactive wastes.

He is the author or coauthor of over 25 technical publications related to nuclear technology, nuclear fuel reprocessing, and radioactive waste management and is active in the American Institute of Chemical Engineers, the American Nuclear Society, American Chemical Society, and the Atomic Industrial Forum. In 1974, Dr. Buckham was awarded the Robert E. Wilson Award by the AIChE in recognition of his outstanding accomplishments. In 1976, he was elected a Fellow of AIChE, and in 1979 he was elected to a three-year term as Director. He is a member of the honorary societies Tau Beta Pi, Sigma Xi, Phi Lambda Epsilon, and Zeta Mu Tau.

Mrs. **Bouquard**. Thank you very much, Dr. Colby.

We will observe the 5-minute rule here and as time permits, we will again go back for more questions.

Dr. Starr, if the fuel cycle and light-water reactor were to become uneconomical, we would need a facility to provide the plutonium for the breeder program. Do you really think this is an important reason to begin reprocessing now?

Dr. **Starr**. I think there are two reasons for starting now on getting the chemical processing underway as an industrial process: One is to develop all the industrial and engineering know-how to do this effectively. The one device we have in being for doing that is the Barnwell plant. Once that plutonium is available, it could be used for either purpose. The option of being able to recycle fuel in light water reactors is one that we should not foreclose, even though the economics today do not show a clear advantage in doing that. We also will need that plutonium for inventorying of the fast reactors. We have time to do both of these things.

I would not say there is only one reason. There are two possibilities as I point out in my paper. One is the economic value that is in the plutonium as a fuel. If the fast breeder capacity grows slowly, that still may be something we may want to do—to use it in light-water reactors—and getting that experience and know-how as an option, not necessarily as a deployment device, is the reason for going ahead.

The second reason is that you want to have inventory for the fast reactor, and that certainly is a valid reason. Those are the reasons for getting on now. Twenty years from now, the reasons may be quite different. Twenty years from now you will want to inventory fast reactors, and that may be your primary reason for wanting to put fuel through a chemical process.

Ms. **Bouquard**. You mentioned the Purex process as used at Savannah River for the fast reactor cycle. Does this mean that our initial programs to obtain plutonium should not use the existing Purex?

Dr. **Starr**. No. I think the Purex process is the only one in which we have any large-scale experience. That is basically the process with some variations that are in Barnwell and all the other processing plants that are putting through fuel today.

The Purex process is not the ideal process from an economics point of view for the fast reactor, but it will produce the same kind of material that a different process would produce. It is the one we have. It is the one, therefore, that we are going to have to move with in terms of getting large-scale experience. We are recommending, and I think everybody in the chemical side of the industry understands, that the development of a cycle optimum for the fast reactor is a different kind of a problem. On a small scale, we have such cycles. EBR-2 at Idaho, which has had a completely different fuel than any of those being concerned now in large reactors, had its own particular type of chemical processing for recycling fuel in that little experimental fast reactor. There are many variations of these processes. They have certain advantages for fast reactors.

It isn't that you can't use the Purex. It is not the best of all systems to match a fast reactor cycle.

Mrs. **Bouquard**. Thank you.

Mr. Gray, you and Dr. Starr talked about the United States taking back spent fuel from foreign nations for reprocessing in exchange for the enriched uranium. Why should these nations agree to such dependence on the United States? What would they benefit from this?

Dr. **Starr**. Well, I will take a crack at it, and then maybe John will, too.

It would be simply that most developing countries, which we work with all the time, incidentally, are putting their front-end capital into the building of light-water reactor power stations. To take that capital and put it into a chemical processing cycle, which today is not necessarily the cheapest thing for them to do in terms of their total energy production, would represent a hurdle for them. They prefer not to use their capital in such a longer range investment. If the major nations of the world will undertake to take the spent fuel off their hands, then they would be just as happy from an operating point of view to get fresh fuel with uranium enrichment.

What they want to be assured of is fuel supply. They have to have a confident source—one that is not going to be politically up and down. If they had that, then their own economics—their own internal development needs—will push them into buying the fresh fuel and getting rid of their spent fuel.

Now the political advantages internationally are quite large. As I and many others have pointed out in our papers on proliferation, if you allow spent fuel to be stored for decades—over 5/10 years—in any one location, the ability to tap that as a plutonium mine gets easier and easier and cheaper and cheaper, and you would like to discourage that down the road, so you don't want that stored everywhere around the world. This is the basis on which we would like to see an international system developed, but the primary motivation would be the economic interest of developing countries.

Mrs. **Bouquard**. Mr. Gray?

Mr. **Gray**. There is a chap who has appeared before some of you over the years—Myron Kratzer—who once was with the State Department. For years, I used to sit with Kratzer, and ask—Why don't you just go buy the spent fuel from countries that treat it as a scrap commodity that is of no value to hold unless they have very expensive facilities with which to process it?

If you look at the economic considerations, it has been the case within the United States that utilities which hold spent fuel have, in one instance that I know of, expressed a willingness to pay PGHS to take it off their hands. This was some years ago.

Spent fuel has no current value. It is scrap—just as scrap steel—it has little value except to those who have the facilities with which to process it. You can in my opinion still have negotiations with those who produce spent fuel about taking it off their hands for very nominal sums that have nothing to do with the prospective uranium or plutonium values found therein because these are not realizable values until significant efforts and capital have been devoted to realizing those values. The whole process is one which, in my opinion, can be directed toward a pick up of spent fuel throughout the world in exchange for relatively nominal sums of money. In my opinion, there is still opportunity to have an ingathering of spent fuel which would be advantageous to the buyer, and to the sellers, from both a nonproliferation and from an economic point of view.

Mrs. **Bouquard**. Thank you very much.

I see my 5 minutes are up.

Mr. Lujan, we will recognize you for questions at this time.

Mr. **Lujan**. Thank you, Madam Chairman.

I can see nothing but positive results from moving ahead with reprocessing. You can see the damage that has been done by the policies of the past administration in shutting down reprocessing. We hear all kinds of arguments saying that there is sufficient uranium for the foreseeable future, at least we heard this from the previous administration. Perhaps this was based on allowing no new nuclear plants but this would not be a practical policy.

I also see Barnwell as a solution sitting there. All we have to do is make the determination.

One thing bothers me, however. I have a young man that travels with me a lot. He likes to get involved in the political process. We went out for a cup of coffee a little while ago. I was explaining to him what has happened with Barnwell, and here it is sitting over there. I said the problem is what are we going to do; what will the Government do? He said, "Well, why not license it?" as it started out. I guess that is the crux of the problem right here. We need Barnwell. We need to move ahead with it.

Dr. Starr, you did not mention Barnwell very much in your testimony. I suppose it is because you think it is cheaper to go ahead and buy the enriched uranium now than to go into processing. It is more expensive. That may be one of the reasons. It appears utilities are not all that crazy about reprocessing for fuel. It, of course, solves the problem for us in waste management.

It has always been my impression that it is crazy to bury spent-fuel rods with the value that is in there. It is like, when a car runs out of gas, just throwing it away.

Anyway, my problem is how do we best utilize Barnwell? I would like to see private enterprise manage it because that way the Government doesn't have to put any money into it, and I think it can be operated more efficiently.

I am a little bit concerned that Dr. Colby says it ought to be owned by the Government and maybe we can come along some way and put something together where there is the users, the beneficiaries, the utilities, end up putting up the money, maybe through a private corporation.

So those two questions: One, why aren't the utilities particularly crazy about Barnwell and then, Dr. Colby, about how we might be able to work this thing around so that Barnwell can be operated as it well should be?

Dr. **Starr**. Let me answer both of those questions or at least from my view address those two questions.

Mr. **Lujan**. Fine.

Dr. **Starr**. One is the utilities are supporters of Barnwell and supporters of going ahead with Barnwell, and I didn't intend—I think if you read my testimony—to leave the impression that Barnwell was undesirable.

I pointed out the need for going ahead with chemical processing experience. Barnwell is the only thing we have to go ahead with, and I don't think there is any question that the utilities feel that Barnwell should go ahead.

The utilities recognize that the chemical-processing cycle at the present time does not fit into the economy of getting low-cost power at the present time. At the present time, it is cheaper to buy from the U.S. Government slightly enriched fuel, and you put it once through the reactor, and store it, but we recognize that somewhere after 10, 15, or 20 years that is no longer going to be true.

Mr. LUJAN. Would it be true if we didn't subsidize the enrichment process?

Dr. STARR. I don't believe you will find that the enrichment plants in the United States are subsidized. I think you will find they are profitable to the U.S. Government, and the enriched fuel is not subsidized as far as our economics show.

Mr. LUJAN. Well, we build the buildings. We have put in $245 million; is that the budget? As a matter of fact that is why we were talking about Uranium Enrichment Associates, to keep——

Dr. STARR. Well, I think if you look at the total Government accounting, you will find you have full cost recovery on the enriched fuel—perhaps, this is a subject for a separate discussion, but I think you will find—that the prices being charged to the utilities for enrichment are representative of full-cost recovery of the enrichment process.

Mr. LUJAN. Let's leave that for today.

Dr. STARR. All right.

The problem with Barnwell and its development is that the utilities cannot justify this on an economic basis at the present time.

On the other hand, we recognize it is going to be needed, and we think it is in the national interest for Barnwell to be supported and developed.

I might point out that the ratepayers—the people who pay for the electricity—are also the taxpayers. There are very few people who are not both at the same time.

Our system of institutions is such that we have no way to recover a very advanced, expensive development program. We can recover parts of this, and we do. We have programs, but they are very small compared to the investment necessary in the national interest and in the public interest.

Let me just point out that we are not cool about this. We are warm about it, but we feel that it has to be undertaken by some other supporting group, other than just the utilities.

Mr. LUJAN. Why the Government then instead of——

Dr. STARR. I think I would let Allied Chemical talk about that issue.

The fact is it will have to be supported one way or another if it is going to proceed.

Mr. LUJAN. Oh, I agree with you. I think we ought to open up Barnwell and start reprocessing. That is my personal feeling.

Dr. STARR. Right.

Mr. LUJAN. I have a little problem with how we do it.

Madam Chairman, is my time up? We can get back to that if my time is used up.

Mrs. **Bouquard**. I am hoping we have another go-around and give everyone more time.

Mr. Wolpe?

Mr. **Wolpe**. I would like to pursue the line of questioning so that there will be continuity here. It seems to me that one of the central issues we are trying to understand is in the light of new economic exigency the Federal Government is facing and in light of a new direction that the administration has laid out, is that we need to rethink the role of government, generally, and to attempt to, where possible, allow the market to do the job of selecting which technologies will fail and which will succeed.

I share the same set of reservations, at least with respect to the economics of the venture that we are into here and the propriety of the Government role. It is along these lines that I would like to ask a few questions.

Am I incorrect in understanding that the Barnwell facility was designed as a commercial venture?

Dr. **Colby**. It was designed, built with private funds as a commercial venture for LWR fuels.

Mr. **Wolpe**. I was intrigued, therefore, to hear Mr. Gray discuss in some depth the need for an elaborate research and development program that would be Government funded and financed.

Is there some suggestion here that, perhaps, the decision to move to a commercial reprocessing plant was premature?

Dr. **Colby**. Relative to the R. & D. program and the needs that are going on down there at Barnwell, at the present time, that program aims at safeguards related activities. As you recall, there was a major change in the course of events when the nonproliferation question reappeared in 1974 and 1975. In fact, most people had believed it had been pretty well addressed in the atoms for peace programs. The safeguards question became very significant with regard to the proliferation issue; and, with the proliferation issue, one has then the development of the safeguards components that go with it. That is related to the R. & D. that has been going on at Barnwell.

Mr. **Wolpe**. Let me just ask the question without reference to the R. & D. component. Is it possible that the decision to build a commercial reprocessing plant was premature?

Dr. **Starr**. Mr. Wolpe, I wonder if I could comment on this from the point of view of the utilities.

At the time Barnwell was undertaken, the utilities were, with Government urging, moving into nuclear power at a great rate. The utilities recognized the long-range need for having a chemical processing plant. At that time, also, the cost of electricity was not very high, relative to what it is now, and the utilities could embody as part of their cost some fraction of the cost in what amounted to at that time a first-of-its-kind plant.

Now there was no question in the utilities mind that they would eventually be able to use the plutonium coming out of that plant, recycle it in light-water reactors or fast reactors and use it as a fuel. There was at the time the certainty of the use of the product.

All of that changed over the past decade. I think that is the real point that is being made.

Mr. WOLPE. I also am very cognizant there are a number of business ventures that have failed over the past decade because the market forces have simply changed.

Dr. STARR. Sure.

Mr. WOLPE. Suddenly, the rate of electrical growth demand has changed, and the projections of available uranium supplies have changed. A lot has changed, not only in the utility sector but across the whole course of the American economy.

I guess the question we need to be addressing is a matter of public policy—should the Government now assume entirely the responsibility for those changes, in the case of the Barnwell reprocessing plant? I mean, is it proper that we essentially—let me just put it point blank—is Barnwell commercially viable today as a commercial reprocessing plant?

Dr. COLBY. As a commercial reprocessing, no, for several reasons: One——

Mr. WOLPE. That's all I need to know at this point.

Dr. COLBY. I think you need to know the reasons why it is not commercially viable. I would think you would like those.

Mr. WOLPE. OK. Go ahead.

Dr. COLBY. It is very important to have a license. It has to be licensed. We do not have licensing proceedings going forward; that is one. Two, we had assumed in 1970 that a waste facility would be built following on the existing plants that we have. We still don't have the slightest idea what the waste form should be. The Federal Government uses waste forms of their own and are moving forward. Those processes are working great. We haven't gotten those answers. We don't know the form and how we could move the plutonium around because of questions that I mentioned earlier relative to proliferation that became very intense in the mid-1970's, so that you can't say Barnwell in its present form under its original intent to be commercial could be made commercial today. It does not mean that it is not a valuable viable national asset to move forward on an economic basis if the U.S. Government program is to have an expanding nuclear program. If we are not to have a nuclear program, Barnwell doesn't make any sense at all.

Mr. WOLPE. Two last questions—what would be the cost under the arrangements that you can contemplate the Federal Government taking over the Barnwell facility?

Dr. COLBY. You mean what is the negotiated price for takeover or what has to happen——

Mr. WOLPE. There is some reference in your discussion to the imposition of some fee arrangement that would minimize the cost to the Federal Government. I am trying to get a handle on what is the magnitude of cost. It could still be a very substantial sum to the Government.

Could you give us, at least with an order of magnitude, an estimated cost to the Federal Government?

Dr. COLBY. I can't give you all numbers because they come out positive. They come out like the enrichment program that was discussed earlier. There is an investment that goes in up front.

There are cost of services or toll fees that come out of it, and those things all come out positive for the use of the services.

In some cases, for example, I believe Barnwell, as an interim storage facility for taking part of the spent fuel and storing it, creates revenues in the early years that are significant. If I use DOE cost numbers, as they would see them, the numbers become very large—$500 or $600 million type numbers.

Mrs. **Bouquard**. Mr. Wolpe, your time is up.

Please, just finish Dr. Colby.

Dr. **Colby**. If the plant is to be run as a full reprocessing plant under the guise initially intended, which is to put in a plutonium conversion facility, as well as the additional waste solidification facilities, so it can run forever or for at least 40 or 50 years for plutonium generation, then you are talking about an investment of $500 million, but you are talking about returns that are many times that amount of investment with regard to the cost of the service, even under the Government accounting rules similar to what is used for in the enrichment program. So I don't think it is a net-cost program at all. It surely is a cost program at the front end, but the dollars would come back, I think, quite rapidly with regard to the mechanisms by which different funding arrangements could be worked out. I don't see it as a major, negative, one-shot outflow, no inflow coming in.

Mrs. **Bouquard**. Thank you.

Before we go ahead with the next member of the committee. I would like to recognize a very good friend, colleague, and former chairman of this subcommitee, Mike McCormack, who is with us today. We are happy to have you with us, Mike, and we are looking forward to your appearing before this committee next Tuesday to give us your views as an overview of the energy needs of our country.

Mr. Volkmer?

Mr. **Volkmer**. Thank you very much, Madam Chairman.

You mentioned that there are three things that prevent you from operating Barnwell as a commercial operation. If those three things were removed, you wouldn't need any money; would you?

Dr. **Colby**. If we could get——

Mr. **Volkmer**. If you had a license and if you had a waste disposal system approved with DOE and if you had a plutonium operation setup, you would have no problem; would you?

Dr. **Colby**. As long as we would know that what happened in the late mid-1970's would not happen again, yes, you could. But I do not see a mechanism by which one can write a piece of a paper between a private organization and the Government that gives you the equivalent protection that the Government has with regard to having that one piece of paper known as title. We are perfectly willing to operate the plant, to see to it that it can be done properly, if that is the choice, but we can't figure out the mechanism by which we can come up with a logical piece of paper that provides the types of guarantees.

A reprocessing plant is a plant which, once when it is turned on and goes hot in operations, must run for the 20- to 30-year type of time frame to get its return back out of it in a very substantial way. All the plants the Government has been operating in that kind of mode, and the rest of the world has been operating that way. We can't have an on-off type of decision in this type of a field, and you can't get people to put up dollars where you do not have some degree of control of the ability to operate your business if you do a good job and be able to run that business into the future. You can't be on the opposite side. This fits into this area, as I have it, as the national security issues. We are not free to license our technology in this area. We were told we could, and then we were told we couldn't. When one finds themselves in that kind of environment, you are basically not able to participate in the free-market system because you can execute everything you need to do but you can't accomplish the business because of all these other blocks, and that is the reason.

Mr. LUJAN. Let me ask you this. As I understand the testimony here, and I don't know if it is 100 percent accurate, reprocessing fuel rods reduces the life time for the waste; is that correct, Dr. Starr?

Dr. STARR. Yes.

Mr. VOLKMER. Which would be in the national interest?

Dr. STARR. Right.

Mr. VOLKMER. Dr. Colby, what if we required every light water reactor facility to reprocess fuel rods and not to dispose of them as such and require them to be reprocessed?

Dr. COLBY. In effect, you are almost there, if you look at the laws of the country. The laws of the country say that the Federal Government is responsible to take wastes, and wastes are to be defined by the Federal Government. If it is reprocessing wastes, which are the kind they are going to be accepting, which is the kind almost all the waste forms are in, then in effect you would have to reprocess your fuel elements, recover and store the valuable uranium and plutonium from them, and put the waste into the form that would be necessary.

That is in effect what the system was assumed to be for 20 years.

Mr. VOLKMER. Dr. Starr, you want to answer. Go ahead.

Dr. STARR. I think there was a key point that went into the original decision which I don't think you ought to gloss over. The utilities were going to buy the plutonium that came out of the plant, use it as mix oxide fuel, mixed with uranium oxide in fuel elements in operating power reactors—first with light water reactors and then with fast reactors. The mixed oxide hearings—that is, the ability for the utilities to burn mixed oxide fuel in their reactors as fuel was stopped at the same time by the same policy. There are no hearings that permit that kind of fuel to be used in light water reactors. So the customer for this plant disappeared. It disappeared at the same time that, all of a sudden, the proliferation issue got to be a big issue and the plant had to be reengineered for proliferation reasons. There are all kinds of things that have happened with the initiation of the antiproliferation policy.

The way to get this process back into being is to permit and to recognize plutonium as a valuable fuel which can be safeguarded, and which ought to be used in power reactors. The utilities will be restored as customers, and the business rationale for the processing system would be reestablished, too, but this takes time. At this point, nobody trusts the U.S. Government, and nobody outside the

United States trusts the United States in the nuclear fuel business because of these ups and downs. Until that gets reestablished, the business environment for the free-enterprise system is not going to exist.

Mr. VOLKMER. I don't think we have the money in the Federal Government to help that out either, though. That is the problem.

Mrs. BOUQUARD. As you have observed, the members of the press are with us today. Without objection, they will be allowed to film our hearings.

Mr. Lundine?

Mr. LUNDINE. Thank you, Madam Chairman.

Perhaps, this is a hypothetical question, Dr. Colby, but do you honestly believe that, if President Ford had never made his decision on reprocessing or decided on the nonproliferation initiative, you would really have gone ahead with the Barnwell project without interruption?

Dr. COLBY. What had happened was that we were moving forward, had completed the plant. In the 1976 Presidential campaign, the issue of proliferation became a political issue. Barnwell, at that time, had completed everything we could move forward with at that point in time.

We were just in the role of going through what is called the GESMO hearings for the recycle of plutonium in light water reactors. That eventually was stopped but, prior to those hearings being stopped, the Barnwell reprocessing program was pulled into those particular hearings as being a part of and a significant piece of the plutonium economy; and, therefore, there was an attempt to try to stop that particular program, as well.

Our response at that point in the system was to say we would run our existing reprocessing plant and facilities that we currently have, but we would like to have a demonstration program on the plutonium piece and on the waste piece from the government because we can't get the answers to that and we don't see the answers forthcoming without a demonstration program. So we proposed to do that at that point in time.

Mr. LUNDINE. But there is need to demonstrate regular commercial reprocessing. It not only has been done in other countries, it has been done in this country.

Dr. COLBY. We have to demonstrate plutonium and waste management. We have to be able to put those materials into proper form. The amount of LWR fuel in this country that has been processed is something like 300 tons total. That is like 10 reactor discharges. We have little experience in this country reprocessing LWR fuel. Our technology for this particular field, and the experience factor now, is residing in Europe.

Mr. LUNDINE. I agree completely that we ought to come to a decision and as definite and firm a decision as the government can ever make that is subject to changes in its leadership regarding reprocessing. We have to do something to deal with the whole regulatory environment. But I am telling you it is my judgment that, one, you have a logical gap in your syllogism when you come to Federal ownership and, two, you are going to have a hard time peddling corporate socialism and bailouts, and all of that, in this

Congress. There is a political environment that I would suggest is likely to be hostile to that.

Now my point is why can't we come up with—if we can resolve to some extent the regulatory issues and if we can determine the extent a year loss—and there is no question there is a loss there—as a result of Federal Government decisions. You said there is just no way that you can be convinced that you have a stable situation, that the risk is too great for not generations, but for centuries. The legal answer to that is a contract.

If we can resolve the policy problems in the Congress as well as within the administration, I don't see why we just couldn't go ahead and negotiate a contract.

The reason I didn't think the first was hypothetical is that, if it was a valid commercial venture then, why can't we—considering what has occurred in the meantime and how that affects your risk and your operations—just negotiate it now?

Dr. COLBY. Do you assume that, in this hypothetical scenario, you can get back to creating the commerical market that existed back in the early 1970's that created the interest on all parties to move forward to not only build this plant, but others, and for people to be competing, and to build additional nuclear powerplants and the use of those products in those powerplants.

If you get that back to that particular position, which I personally believe is the place we should be now, with regard to our nuclear power program and we wouldn't have the imported oil problem, then I think you would have a viable industry; but, just by saying we have a public policy issue—we are going to go back and now change things—I don't necessarily see plutonium recycle in thermal reactors followed by the breeder program with new reactor orders coming on line at the same rate with regard to those markets.

I don't know, and I said I have not seen or had an attorney tell me that there is a viable contract that can be written between a private organization and the Government that gives the equivalent of protection to that private organization with regard to it's change of a title of that facility owned by the Federal Government. I don't know of one in this area.

Mrs. BOUQUARD. We now have 15 more minutes before we have to move out of this room. There are five of us, so we are going to go now to the 3-minute rule and hope that we can all abide by it. Mr. Lujan?

Mr. LUJAN. Thank you. I will get right down to it.

I agree with you, Dr. Starr, that the problem is the confidence of what the government will do by Barnwell. Obviously, Dr. Colby says we don't trust them. By foreign purchasers, we have that lack of confidence.

If Barnwell is, at the moment, unwilling to take that chance of operating it as a commercial venture—if we have the climate to come up with $360 million—it is almost an impossibility in this day and time—do you think that it is possible to have a public corporation or government corporation that could issue bonds and pay it from its revenues—some sort of a mechanism like that, as between the government itself or private company operating it?

**Dr. Colby.** Yes, I think there are alternative mechanisms to a mechanism that says that DOE has to purchase Barnwell and make it a part of the military complex at Savannah River. I think there are different mechanisms that need to be evaluated.

I do believe that the word commercial reprocessing as it applies has changed so drastically because of the lack of the markets, because of these changes we have gone through, that I really am looking at Barnwell as a national asset because of the fact it is there and can do all these things that are necessary with regard to our future nuclear program.

**Mr. Lujan.** One other thing that I would like to point out that is very important—that we get Barnwell cranked up. Besides the question of dollars, the question of reprocessing those spent fuel rods, which are piling up at all the various sites. That is probably one of the most important contributions, that we go ahead and solve the waste problem. Barnwell is there to help us solve that waste problem. Everybody just throws up their arms in despair because it is said we are not moving ahead with solving the waste problem. Certainly that is one of the big contributions.

**Dr. Colby.** I agree it would be a major contribution, but I would not want the committee to be misled. As I mentioned in my testimony, Barnwell, if your decision today was to move forward with it and get it running as quickly as possible, your theoretical earliest date for sustained operation would be in 1987—6 years into the future.

**Mr. Lujan.** Do you mean for you to start reprocessing?

**Dr. Colby.** For us to start reprocessing with all facilities operating is sitting at least 6 years into the future.

**Mrs. Bouquard.** Mr. Volpe?

**Mr. Volpe.** Does the gentleman from Missouri have a question?

**Mr. Volkmer.** Yes; I would just like to continue on that, real fast.

Between now and 1987, at what total cost?

**Dr. Colby.** I can give you the capital number. If you build the plutonium and waste facilities you assume a cost of somewhere between $500 million and $700 million.

On the other hand, you could run a limited reprocessing program with the existing plant for several years and defer the decision on the $500 to $750 million for a later time.

**Mr. Lujan.** Of how much?

**Dr. Colby.** If you add capital, it is $500 to $750 additional. If you don't add additional capital—you are talking just about the maintenance cost of operating a facility like that—which is of the order of $10 million a year capital project, plus the revenues coming back from the alternate programs. They are self-sustaining kinds of programs. Net? I can't tell you the cumulative cost and the cumulative income associated with it. I can give you capital and I can tell you it is within the realm of normal expenditures for operating that facility similar to the way Savannah River operates.

**Mr. Volkmer.** I just have another quick question, following what the gentleman from New Mexico also said earlier about a public corporation—something in that order—and knowing that private utilities—everybody is supporting the reopening of Barnwell. Instead of having a charge-off, but give them a credit so we get money up front, we allocate a tax or a fee for every fuel rod that a utility has used in the generation of electricity for, say, the last 3 years—or something like that—and we get the funds that way, and then every year thereafter, everytime they push out a fuel rod, they are going to have to kick in some money?

Dr. COLBY. I think it could be done that way. I think it can be done on an advanced payment basis for a smaller number of fuel rods.

Mr. VOLKMER. But for looking at the future as to a reprocessing as a necessity and something we should get to, I think we ought to take them right as they are pumped out of the powerplant into the pool, and that is when you do it, so that we know they are not going to lay around there forever.

Dr. COLBY. That is right. That amount of money would not be much under that arrangement. There are additional revenues——

Mr. VOLKMER. Which they could recover from the consumers.

Dr. COLBY. Yes. There are additional revenues you could recover from overseas. The technology here can be licensed and for significant sums overseas.

Mrs. BOUQUARD. Mr. Wolpe?

Mr. WOLPE. Dr. Colby, what would be the front-end cost—only the front-end cost—at this point, understanding that there may be other revenues that would then accrue back to the Federal Government in some fashion down the road? What would be the additional front-end cost, in your judgment, of the proposal that you are advancing, which is government takeover a facility?

Dr. COLBY. When you say "front-end cost," I am going to interpret that as what is the asking price for the facility.

Mr. WOLPE. OK.

Dr. COLBY. We have said that our costs—and that is what we wanted to get back—were $362 million. Those costs were generated through our capital accounts, plus our interest at bond rate interest, all summed up to the end of 1978. Those numbers turn out to be $362 million. We feel that, as an asking price, is a very fair asking price, especially if the plant is to be used for reprocessing. It's replacement value is well in excess of $500 million.

Mr. WOLPE. When you asked how I interpreted a front-end cost, you worry me a little bit. Are there some other other costs which I should be inquiring into at this point?

Dr. COLBY. Only the additional costs that are the annual expense costs—like you need to support the staff and do the various other kinds of things. Those have to be covered, and I just didn't know whether you wanted those included.

Mr. WOLPE. What would be the magnitude of costs there?

Dr. COLBY. As we mentioned in the statement, we have a staff that we have been doing R. & D. programs down there at about $18 million a year total, of which $11.5 comes through the base program, as we call it, and $6 million comes from various other types. So you would be looking at that level to support a staff of 350 people. That number of people would increase quite dramatically and move up into the 1,100 or 1,200 number if in fact you went forward for a reprocessing during the next 3 years, and so you would scale those costs up appropriately.

A full operating plant at Barnwell is about 1,200 people. It may be more if you add fuel fabrication, and the operating budget under those conditions is something of the order of $50 or $60 million. The return is the revenues that come from that, which is really quite spectacular.

Mr. **Wolpe**. Thank you.

Dr. Starr, there is this phrase on page 3 that kind of caught my attention. I would just like to quote from the paper. "Although it is the conventional wisdom that the cost of chemical processing is sufficiently large to make the extraction of plutonium for recycling as a fuel into light water reactors not attractive at the present time, it is evident to most of us who study technical and economic trends that sometime early in the next several decades * * *"—that is an interesting way of pinpointing the time—"* * * the economics of recycle may be sufficiently attractive that this might become a desirable part of the nuclear fuel cycle."

Now I appreciate your caution, but is there any greater precision that you could put on that kind of estimation?

Dr. **Starr**. Well, the reason I am vague about the time is that there are too many factors that have to be predicted to find out when the time would be. The available uranium around the world is likely to increase, but we don't know exactly how fast, because its price will depend on what happens outside the United States.

The development of the chemical processing cycle that we just talked about—if Barnwell started operating and we found that the unit cost of processing materials started dropping fast, which is traditional in an industrial process, that brings the time shorter.

The licensing for mixed oxide fuel and its performance in reactors—if that had to go through and we have good experience with that—all of these things could happen in a matter of 10 years. That could happen in 15 years. We don't know exactly when. We know that, eventually, that is going to happen. We just don't know when.

Mrs. **Bouquard**. Mr. Lundine, just 2 minutes.

Mr. **Lundine**. Would it be necessary for Barnwell to be used as an away-from-reactor storage site for it to be commercially feasible. In other words, I don't happen to favor AFR's, but I can see where additional fees would come to whoever operates it, for the interim storage, and I wonder whether that is a necessary part of making any project commercially attractive?

Dr. **Colby**. Well, it depends on whether you are trying to maximize revenues or not. If you are trying to maximize the revenues, it can be helpful to help offset those. On the other hand, some aspect of storage, will be required prior to its operation as a reprocessing plant, and you need to bring that in. If one is to bring it in 2 or 3 years in advance, you would call that just prior to reprocessing. If you bring it in 5 years in advance, you would call that interim storage. I think it is marginal. There is no reason why one should not take advantage of the existing pool and maximize the revenues and use it, not as an AFR indefinitely by any means, but use it as a cumulating fuel prior to processing.

Mr. **Lundine**. With the thought you would reprocess that fuel?

Dr. **Colby**. Of course, yes, sir.

Mr. **Lundine**. Thank you.

Mrs. **Bouquard**. Since we have run out of time, I am going to ask you to submit the answer to my question in writing.

What mechanism would you suggest to provide the necessary confidence to the committee and to the Department that the design of the Barnwell facility is acceptable and will not result in long-term cost liabilities, and what institutional arrangements could be investigated for ownership and operation of the Barnwell facility if it is activated?

I certainly appreciate your being with us today and your valuable testimony.

This committee will meet next Tuesday afternoon at 2 p.m.

The committee now stands adjourned.

[Whereupon, at 9:50 a.m., the subcommittee adjourned to reconvene on Tuesday, March 10, 1981.]

[Questions and answers for the record follow:]

AGNS
Allied-General Nuclear Services

**Jerald V. Halvorsen**
Vice President
Governmental Affairs

March 9, 1981

Honorable Manuel Lujan
Ranking Minority Member
Subcommittee on Energy Research
and Production
Committee on Science and Technology
US House of Representatives
B-374 Rayburn House Office Building
Washington, DC 20515

Dear Congressman Lujan:

At the conclusion of your Subcommittee's March 5 hearing, you requested written answers from Dr. Colby on four questions. Attached are our answers to those questions.

We would be pleased to provide you with any additional information on the Barnwell program that you believe would be helpful.

Sincerely,

Jerry Halvorsen

Jerald V. Halvorsen

JVH/jle

## ANSWERS TO QUESTIONS FROM CONGRESSMAN LUJAN

1.) QUESTION:

If Barnwell rents AFR space, how much income per year?

ANSWER:

Fees for the 1750 tons that could be stored in a reracked Barnwell Nuclear Fuel Plant (BNFP) fuel storage pool prior to reprocessing would exceed $600 million, according to an October, 1980 report entitled "Department of Energy Report on Fee for Spent Nuclear Fuel Storage and Disposal Services." At full operating capacity of 1500 tons per year, the utility fees would exceed $500 million per year, which is adequate to pay back the costs of constructing the balance-of-plant facilities at BNFP within a few years as well as to cover terminal waste disposal costs.

2.) QUESTION:

Will this income be enough to operate?

ANSWER:

These fees would be enough to cover operating costs at the BNFP in addition to a moderate profit to the operating contractor.

3.) QUESTION:

Any left over to rerack?

ANSWER:

These fees are intended to include and are adequate to cover the cost of reracking.

4.) QUESTION:

Any left over to pay interest on bonds? Any left over to pay back on the bonds?

ANSWER:

In response to these questions, one should again reference the October, 1980 DOE report mentioned above. This report states that: "This fee has been developed from DOE program information on spent fuel requirements, facility availability, facility cost estimates, and research and development programs." The discounted cash flow technique has used the most recent estimates of cost of borrowing by the Federal Government.

AGNS
Allied-General Nuclear Services

Jerold V. Halvorsen
Vice President
Governmental Affairs

March 9, 1981

Honorable Marilyn L. Bouquard
Chairman, Subcommittee on Energy Research
and Production
Committee on Science and Technology
US House of Representatives
B-374 Rayburn House Office Building
Washington, DC 20515

Dear Madame Chairman:

At the conclusion of your Subcommittee's March 5 hearing, you requested written answers to two questions. Those questions and our answers are as follows:

QUESTION:

What mechanism would you suggest be utilized to provide the necessary confidence to the Committee and to the Department that the design of the Barnwell facility is acceptable and will not result in long-term costly reliability problems?

ANSWER:

The Barnwell Nuclear Fuel Plant (BNFP) was constructed with thorough quality assurance procedures to help meet its design objectives. All testing conducted to date has indicated that these procedures were effective in the construction of the Barnwell Plant. The equipment that might require maintenance has provisions for remote replacement or repair, and all of these provisions have been successfully tested during preliminary operation of the facility on a cold run basis. The equipment not expected to require maintenance or replacement has provisions for contact maintenance. In a few specific cases, our cold testing program has revealed that some equipment should be relocated for remote maintenance before startup to provide for greater reliability in operation. In addition, an independent team of experts sponsored by the Electric Power Research Institute (EPRI) has unanimously endorsed the operability and maintainability of the BNFP, and endorsed our plan to consider relocating some pieces of equipment to provide greater reliability. We believe that the reviews of the Plant and its operability that have been conducted to date should provide the Committee with a high degree of confidence that the Barnwell Plant will operate reliably. Should the Federal Government acquire the Barnwell Plant, the Department of Energy would have time prior to acquisition to perform a final check on the Plant's systems and make necessary changes to improve even further the Plant's operational on-stream reliability. However, the only absolute confirmation of the Barnwell Plant's reliability will come from startup and operation of the facility. If the Subcommittee requires further assurances, an independent panel of experts should be assembled to further evaluate the design and operability of the BNFP.

QUESTION:

What institutional arrangements do you recommend be investigated for ownership and operation of the Barnwell facility if it is activated?

ANSWER:

There are a number of possible arrangements for Government ownership and operation of Barnwell. These would include a government owned, contractor operated arrangement. To more fully explore this and other potential arrangements in detail, the Department should be directed, with the assistance of outside management experts, to evaluate all feasible options for Government ownership and operation of Barnwell and report back to the Committee on a timely basis.

We would be pleased to provide additional information on the above subject areas.

Sincerely,

Jerald V Halvorsen

Jerald V. Halvorsen

JVH/jle

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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## TUESDAY, MARCH 10, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 9 a.m., in room 2318, Rayburn House Office Building, Hon. Marilyn Lloyd Bouquard (chairman of the subcommittee) presiding.

Mrs. Bouquard. The hearing will come to order.

Good morning, ladies and gentlemen. We have, once again, several distinguished witnesses with us to discuss energy issues related to the Department of Energy's fiscal year 1982 authorization request.

This is the last hearing that we will hold exclusively with outside witnesses and we expect it to be a general issues hearing which touches on major policy directions for the new administration and the Congress.

This morning Mr. Mike McCormack, who is the past chairman of this subcommittee, will be along a little later, and will provide us with his unique perspective on the challenges and opportunities for the nuclear fission and magnetic fusion programs over the next several years.

We also are fortunate to have Mr. Conway and Mr. Kearney from the American Nuclear Energy Council who will give us industry's view on DOE programs and policy.

Then, beginning next week, we shall have the DOE here to discuss the details of the fiscal year 1982 budget. We are under a very tight timetable beginning with tomorrow's subcommittee meeting on preliminary budget estimates for fiscal year 1982.

At next week's meeting with DOE, some non-Government witnesses will also participate in the area of ongoing nuclear programs. The subcommittee will then mark up the Reagan administration's fiscal year 1982 budget request on March 24, 25, and 26.

I am looking forward to some refreshing suggestions from our witnesses this morning.

Welcome.

I think we will begin with you, Mr. Conway. You may proceed with your testimony.

### STATEMENT OF JOHN T. CONWAY, PRESIDENT, AMERICAN NUCLEAR ENERGY COUNCIL

Mr. Conway. Thank you, Madam Chairman.

With your permission, I will submit my prepared statement for the record, as if it were read, and then I would like to speak maybe for 10 or 15 minutes on the general local view of the problem.

Mrs. **Bouquard.** Without objection it is made a part of the record and please proceed.

Mr. **Conway.** Thank you.

Yesterday, March 10, the New York Times in its editorial raised a question about the support for the so-called nuclear budget. It had a question as to "Why shouldn't we cut the nuclear budget," and then went on to be very critical of the Government's support for the Clinch River project. I think the New York Times is in error in the position it took in that editorial yesterday.

If I may, I would like to go back and do a quick thumbnail sketch of the nuclear civilian program as it evolved in the Government and with industry.

As you will recall, prior to 1954, no utility in the United States could build or operate a nuclear powerplant. It was exclusively the prerogative of the U.S. Government until the Atomic Energy Act of 1954 was passed by Congress.

The Congress, after a long debate that went into late hours and involved a very famous filibuster, voted out the 1954 Atomic Energy Act which was directed toward trying to move nuclear power more into the civilian area.

The Congress found and the President of the United States agreed, when he signed that bill, that it was in the national interest for the United States to proceed with the peaceful uses of atomic energy. Thereafter Congress voted out a number of cooperative programs encouraging the elecric utility industry, both private and public, to participate with the Government in the development of the civilian uses of nuclear power. It was the understanding of the Congress and executive branch of the Government that an adequate supply of electric energy for the United States was essential to our security and to our economic viablity.

Practically all of the technology in the nuclear field prior to 1954 was in the Government laboratories and the utility industry was encouraged to come in and work with the Government and become knowledgeable in this field and to try to move ahead in putting nuclear powerplants on its systems.

In the early days of building nuclear powerplants, we were able to build a plant and put it on the line in the order of magnitude of 5 to 6 years.

Today, it is taking us up to 15 years from the time a decision is made by a utility to proceed with the nuclear powerplant until it actually gets on the line and goes commercial. The difference in time it is now taking us mainly is due to nuclear regulatory reviews by numerous Federal and State government agencies in some cases, but particularly the very detailed procedural requirements that have been imposed by the Nuclear Regulatory Commission.

It now takes industry, notwithstanding much more knowledge on the part of the utility industry on how to build and operate nuclear powerplants, more than double the time to put those plants on line.

That I think can be corrected and hopefully in the coming year we will see some administrative changes in which will cut back this, what we believe to be unnecessary time delays.

Obviously, the longer you wait to get a plant on line and the longer you take to get it constructed, the more costly for the consumer of electricity. We have estimates today with respect to new powerplants going on line, that at least half a billion dollars in additional cost is due to delays in licensing procedures.

We have not as yet seen the Reagan administration's budget, but we understand from statements emanating from the Secretary of Energy and also from the White House, that the Clinch River breeder project will be funded.

For the last 4 years the past administration has not been supportive of that project, although the Congress, and I believe wisely has seen fit to continue to support the project and we in the nuclear industry are strong supporters of the project.

The evolution of the plant goes back to 1962. In 1962 there was a detailed analyses made in the executive branch as to whether or not this country should proceed with a breeder reactor.

The conclusion of that report, which was a report to the President of the United States, the President being President Kennedy, was that it was essential to the future needs of this Nation to proceed with the breeder reactor.

The report went to the President and he agreed with it and that was the beginning of our breeder program.

As we moved ahead in the basic R. & D. program and more into Government sponsored applied research, and we got to the point where the executive branch and the Congress decided it was time to move ahead with some demonstration of breeder reactors. It was the Government that went out to the industry and asked the industry to come in and cooperate with the Federal Government in the building of CRBR plant.

The utilities industry, both public and private, joined together in what was then one of the largest cooperative programs ever put together and in the order of $250 million was raised up front by the utilities industry in response to the Government's request to come in on that program.

That program proceeded along we think, very well, until the past administration, for one or more reasons, decided they wanted to cut that program back. In fact, they wanted to terminate the program.

Now, that was a program that was initially initiated by the Federal Government and the utilities industry came in, in response to the request of the Government, and, the industry is still supportive of it.

Mr. OTTINGER. Excuse me. Are you now talking about Clinch River?

Mr. CONWAY. Yes, sir.

Mr. OTTINGER. Or the advanced breeder?

Mr. CONWAY. I am talking about the Clinch River project, yes, sir.

As I say, I can't be more complementary of the Congress for having studied this over the last 4 years and notwithstanding the pressures from the executive branch, in supporting that project. We in the industry continue to support it and believe it is a good project that should be brought to fruition. One of the complaints also in the New York Times article yesterday was to the effect that the nuclear budget is being increased, whereas a number of other deserving projects are being cut back. It made it look like the serious cuts in the other projects were being made to help the nuclear program.

If I can go to page 15, where I discuss the nuclear power budget. I think it is important if I may read just this page and the next page for the committee.

> The Carter Administration virtually brought to a halt work to close the back end of the fuel cycle. As shown, from the standpoint of domestic economics, national security and international prestige, the Reagan budget must reflect the recognition that coal and nuclear power are the only economic alternatives for large-scale application in the remainder of the century.

I say that based on the most detailed study undertaken by the National Academy of Sciences. They, on the request of DOE, undertook a 3-year study that, as I recall, cost in the neighborhood of $4 million. At the completion of the study it was the conclusion of the best technical minds in this country, that coal and nuclear power are the only viable method of base-load elecric energy for the remainder of the century.

A review of the nuclear budget over the past several years clearly shows that in relation to the overall DOE budget and the funding afforded other energy research, development, and demonstration programs, nuclear program funding has declined.

I have attached to my prepared statement attachment 3 which shows that the nuclear fission budget has declined by 15.4 percent since 1977 in terms of year of budget dollars. In real terms, taking inflation into account, the reduction of nuclear funding is even more dramatic, amounting to a 42-percent reduction in constant fiscal year 1981 dollars.

A number of those that are not supportive of nuclear power have adopted the strategy for fiscal year 1982 of attacking the nuclear energy portion of that budget by projecting it as a disproportionate share of the total DOE budget. This is accomplished by adding to the nuclear energy total, funding for military applications, nuclear science applications, and the uranium enrichment program.

Clearly military and science applications have no bearing on the nuclear energy component. That applies to the civilian portion of the program. Nor should uranium enrichment program funding be included because the program is operated, as required by law, on a 10-year campaign full-cost recovery basis.

Moneys that go into the enrichment program are eventually paid for by utilities using the service, domestic and foreign, and obviously eventually paid for by consumers of the electricity.

The nuclear energy component of President Carter's fiscal year 1982 budget for DOE amounts to $959 million. Even this amount for nuclear funding includes costs incurred by the Government for commercial waste management and spent-fuel storage programs which will be returned in the form of fees paid by the utilities for the utilization of such services once the programs have become operational.

The $959 million in the Carter budget represents only 6 percent of the total DOE budget of $16.5 billion and 17 percent of the conservation and energy research and development sectors. The nuclear budget must be increased if the downward trend in nuclear program funding is to be turned around and if nuclear power is to contribute its full potential to establishing energy security for the United States.

With that, Madam Chairman, I would like to turn it over to my associate, John Kearney, who is a senior vice president of the Edison Electric Institute.

[The prepared statement of John Conway follows:]

# *STATEMENT*
# BY
# JOHN T. CONWAY
# PRESIDENT
# AMERICAN NUCLEAR ENERGY COUNCIL
# BEFORE THE
# COMMITTEE ON SCIENCE AND TECHNOLOGY
# HOUSE OF REPRESENTATIVES

March 10, 1981

My name is John T. Conway. I am President of the American Nuclear Energy Council -- a nuclear trade association located in Washington, D.C., with a membership of over 100 organizations including private, public and cooperatively owned utilities, manufacturers, architect-engineers and various firms in the nuclear fuel cycle. The Council supports energy conservation and the development of synthetic fuels, solar, fusion and other longer range energy resources, but holds that nuclear power is essential if this Nation is to have adequate and dependable energy supplies during this century. It believes that energy sufficiency can be achieved only by vigorous utilization of domestic coal and nuclear energy.

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John T. Conway formerly was Executive Assistant to the Chairman of the Board, Con Edison, New York, for 10 years. For eight of those 10 years he was Chairman of the Nuclear Facility Safety Committee which had overall safety responsibility for Indian Point Units 1, 2 and 3. He has a BNS and BS in Engineering from Tufts College of Engineering and an LL.B. from Columbia University School of Law. From 1956 to 1968 he was on the staff of the Joint Committee on Atomic Energy, U.S. Congress.

Both Presidents Carter and Reagan have stressed the need to take prompt action to restore economic health to the Nation. They have called for the revitalization of American industry, improved productivity and increased employment opportunities. Additionally, they have focused the Nation's attention on the need to reduce our dangerous dependence on foreign oil imports - dangerous not only from the standpoint of its deleterious economic impact on our balance of payments deficit and domestic rate of inflation, but also from a strategic and geopolitical standpoint.

Foreign oil amounts to nearly half our petroleum requirements and could cost between $80 and 100 billion this year.

To place this staggering cost in a framework for easy understanding, I would note that at today's stock market prices: General Electric is valued at $11.4 billion; Westinghouse at $1.9 billion; Combustion Engineering at $0.96 billion; and McDermott, Inc., parent company of Babcock and Wilcox, at $1.1 billion.

This totals out at $15.4 billion. Imagine one year of foreign oil imports being six-fold in value to these four giant American enterprises that provide jobs for over 700,000 people and an astounding variety of goods and services at home and around the world.

I singled out these four corporations for they are the manufacturers of major equipment for electric power plants - both nuclear and fossil - in America and their eminent success at this is acknowledged throughout the world.

If the Nation is to meet the goals set forth by both President Carter and President Reagan it must, in addition to adopting conservation measures, continue the trend toward increased substitution of electricity for oil. It is here that nuclear energy can and must make a significant contribution.

In my comments today, I should like to review the need for increased production and substitution of electrical energy for oil; the role to be played by nuclear energy as a key component of our national energy mix; the impact of licensing delays on the nation's nuclear energy program; and major aspects of the forthcoming Reagan budget.

## I. The Need for Additional Electrical Generating Capacity

Electricity is sometimes termed inefficient fuel usage because of thermal conversion losses, and therefore direct heat sources of power are promoted as preferred alternatives. However, this view ignores electrical end-use efficiencies which, in many cases, more than compensate for conversion losses. There are two interlocking strategies which underlie efforts to displace oil imports through production of electricity by utilities. The first involves displacing oil consumed in the generation of electricity by oil to coal conversions of existing power plants and by completing on schedule coal and nuclear units under construction. A second strategy involves increased electrification to replace oil at end-use. The latter strategy is often overlooked, but offers significant potential to reduce U.S. oil consumption. It is our position, and that of the National Academy of Sciences,[1] that increased use of electricity is essential to reducing U.S. dependency on foreign oil and to providing adequate energy supplies for a growing economy. That exhaustive study by the National Academy of Sciences concluded: "Coal and nuclear power are the only economic alternatives for large-scale application in the remainder of this century."

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[1] The National Academy of Sciences' Committee on Nuclear and Alternative Systems report "Energy in Transition: 1985-2010" submitted to the U.S. Department of Energy on January 14, 1980.

Substitution of electricity for oil is now viewed as the goal for several segments of the economy:

- residential/commercial space conditioning;
- low temperature industrial and commercial heat;
- high temperature industrial direct heat;
- intracity passenger and freight transport; and
- high density rail transport.

The potential market for which electric energy can substitute for oil is impressive indeed. If assured suppliers of electricity (whether from coal or nuclear or hydro) are available, and appropriate national policy and regulatory pricing policies are adopted, we believe electricity can and will capture a significant portion of this potential through marketplace forces. The result would be substantially less dependence on imported oil.

If one assumes that in the 1980's electricity replaces half of the potential for space and water heating and for oil and gas-fired electric generation, and only 10 percent of the potential for industrial use (and none in the transportation sector), the United States would reduce its oil consumption by 3.5 million barrels of oil per day (20 percent of current consumption) by this mechanism alone. But to do so, and also accommodate even a very modest 2 percent growth per year in electricity for nonsubstituting functions, would require that our total coal, hydro and nuclear electric power production be nearly doubled in this decade.

Additionally, substantial improvements in efficiency of energy input vs energy produced per unit are projected. These improvements are expected as a result of efforts to reduce outages in large base load plants and improved reliability in all aspects of the system. New high voltage transmission lines can also reduce system losses. One major utility has calculated that a 30 percent reduction in transmission losses would provide enough additional capacity to supply electricity to cities the size of Oakland, California or Louisville, Kentucky.[2]

## Electrical Growth Projections

Despite the sudden and cyclical changes that have characterized the ratio of total energy growth to GNP, a close and stable relationship has existed between electricity usage and economic growth. This trend is expected to continue. Studies by the Electric Power Research Institute and the National Electric Reliability Council indicate that electric power requirements will grow at an average annual rate of nearly 4½ percent to the end of this century.[3] These studies conclude this rate of electrical growth is necessary to sustain an intermediate economic growth rate of 2.9 percent which must be compared to the 3.5 percent economic growth experienced between 1960 and 1970. By 1985, it is expected that about 35 percent of all energy used in the United States will be devoted to generation of electricity, compared to some 30 percent in 1979. By the year 2000, this figure will reach almost 50 percent. In that year, electricity requirements are expected to be about 2½ times the 2.3 trillion kilowatt hours used last year.[4] U.S. census data assumes by that year there will be a population of 260 million with a work force of 135 million -- a 41 percent increase from the 96 million in the labor force today.

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[2] Electric Power Research Institute "1981-1985 Overview and Strategy" Executive Summary, October 1980. 600 MW is roughly the generation capacity required for a city of 360,000 persons. According to the latest 1970 census data, Oakland and Louisville each had populations of some 361,000 persons.

[3] National Electric Reliability Council "10th Annual Review of Overall Reliability and Adequacy of the North American Bulk Power System", August 1980; Electric Power Research Institute "1981-1985 Overview Strategy", October 1980.

Some studies choose to assume as a planning base a low economic growth rate of 2.5 percent accompanied by a 3.5 percent electrical growth rate. However, we share EPRI's view that past trends in economic growth have increased the Nation's expectation for future growth particularly for the people at the lower end of the income spectrum. It, therefore, is not only prudent but essential that the national planning base reflect a likely economic expectation and project energy supply goals the Nation should strive to reach in order to maintain this expectation.

EPRI finds that even with optimum development of coal, renewable resources and planned nuclear generation, an electricity shortfall is projected between the mid-1980's and the year 2000. Whether a low 2.5 pecent or an intermediate 2.9 percent economic growth is assumed, the size of the shortfall is dependent on the available levels of nuclear power as the key swing fuel, making up the differences between coal, gas and oil, renewables to meet electrical requirements.

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[4] Included in this projection is the assumption that conservation will be required to make a significant contribution. In 1979 alone, energy savings totaled 4 quads. By the year 2000, a difference of 38 quads exists between the pre-oil embargo economic growth rate of 3.5 percent and the study's intermediate rate of 2.9 percent.

The projected shortfalls will be felt in some combination of reduced economic activity, substitution of more costly oil and natural gas energy resources and more extensive conservation measures.

## II. The Need for Nuclear Power is a Domestic Economic Issue

As of February 1981, there are 71 civilian nuclear power plants in operation in the United States with a capacity of about 53,000 MW(e). In addition, two plants, 1000 MW(e) each, are licensed for low power testing; 82 plants, 91,000 MW(e), are under construction; and 11 plants, 14,000 MW(e), are under construction review. In total, this amounts to 166 plants representing approximately 160,000 MW(e).[5]

Nuclear power is currently producing 11 percent of the Nation's electrical requirements. This contribution will dramatically increase as nuclear power plants currently being constructed are brought into commercial operation. By 1989, nuclear power plants should be producing 26 percent of the Nation's electricity. Beyond 1990, nuclear's contribution increases to over 30 percent by the year 2000, depending on assumptions related to economic and energy growth.

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5. This data excludes: Dresden 1 - 200 MW(e); Humbolt Bay - 65 MW(e); TMI 2 - 906 MW(e) closed indefinitely; Indian Point I - 265 MW(e) with decommissioning plans underway.

Critics sometimes suggest that nuclear energy can be easily phased out by comparing nuclear's contribution as a relative percentage of total energy supply which DoE estimates to be about 4.4 percent in 1979. Such statements are misleading and irrelevant since about 50 percent of total energy supply comes from oil alone. Moreover, as we point out below, a small percentage of a very large number is still a large number.

## Nuclear is Making a Substantial Contribution to Reduction of Oil Imports

Last year nuclear power provided the equivalent of 1.3 million barrels per day of oil equivalent (bde). This generation is roughly the energy equivalent to the current Alaskan oil production level and is also equivalent to our total imports from Saudi Arabia. The 1973-1974 Arab oil embargo resulted in the loss of less than 500,000 barrels of oil per day, but it put over one million people out of work and cost some $40 billion in the gross national product. Each new 1000 MW(e) reactor in commercial service will additionally offset the equivalent of 30,000 barrels per day (bde). If the 93 plants under construction or on order are completed during this decade, the nuclear contribution is expected to be 4 to 4.5 million barrels of oil per day of oil equivalent (bde).

Even with the planned capacity additions, both coal and nuclear, EPRI projects shortfalls in electrical capacity in the year 2000 by about 100 gigawatts (1 gigawatt equals 1000 megawatts which equals 1 million kilowatts) for both low and intermediate growth projection. This shortfall can only be made up by increased nuclear and coal capacity additions. Whether these additions materialize depends on whether the constraints retarding the growth of nuclear capacity are removed.

In 1973, consumers paid about $70 billion for oil and our oil imports cost us $8 billion. This year, consumers are paying at a rate of $300 billion a year and our oil imports will cost us $80 to $100 billion dependent upon OPEC prices (i.e., energy costs went from 6.5 percent of GNP in 1970 to 15.8 percent today, paced mainly by oil that went from 2.2 percent GNP in 1970 to 9.1 percent today).[6]

## Economics

It should be noted that nuclear power continues to provide the lowest cost, most reliable and environmentally acceptable source of baseload electricity. Economic estimates prepared by DoE, as shown in Attachment 1 indicate that emerging technologies, such as photovoltaics, will not be competitive with coal and nuclear energy for the generation of electricity through this decade. For example, the delivered cost for space heating of electricity generated by photovoltaics is projected to cost, by 1990, $36-48 per million BTU and is equivalent to $170-240 per barrel of oil. In comparison, coal and nuclear are projected to cost $12-17 per million BTU an equivalent of $40-70 per barrel.

## Safety

Additionally, a growing body of evidence points to dramatically lower releases of radioactivity in a serious accident than the Nuclear

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[6] EPRI Journal, December 1980. "Energy Conservation, Efficiency and Substitution", by Arthur M. Bueche, estimates oil imports at $82 billion at current prices.

Regulatory Commission's requirements and guidelines presuppose. In 1980, scientists at the Electric Power Research Institute in Palo Alto; Oak Ridge National Laboratory; Los Alamos Scientific Laboratory; the Nuclear Research Center in Karlsrue, Germany; and the Holden research reactor in Norway independently concluded that NRC's core-meltdown scenarios tend to exaggerate or misconstrue the behavior of certain radionuclides under those conditions.

## The Need for Nuclear Power is a National Security Issue

In addition to the economic penalty of depending on foreign sources for a third of the United States' oil, the strategic and political implications are of grave concern.

A recent colloquium, "Contingency Planning for an Energy Emergency", conducted at Stanford University, noted that a total shut-off of Middle East oil could result in a shortfall of 6 million barrels of oil per day.[7] The anticipated domestic impacts included 8 million additional unemployed; a drop of $3,000 in annual disposable income per family; and impaired ability to mobilize effectively to defend ourselves. At this point, I should like to submit a copy of the Statement of Colloquium (Attachment 2) for the record.

Of a more subtle nature, but also of concern, is the vulnerability such dependence assures to political pressure.

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[7] "Contingency Planning for and Energy Emergency", June 16-18, 1980 at Stanford University, co-sponsored by the Hoover Institution and Scientists and Engineers for Secure Energy.

## The Need for Nuclear Power is a Foreign Policy Issue

The 60-odd nations and four international organizations that participated in the International Nuclear Fuel Cycle established not only that nuclear energy is viewed internationally as critical to the energy mix, but that several national nuclear programs have surpassed those in the United States.

The international nuclear energy commitment currently includes 179 plants in operation; 160 under construction; 27 on order; and an additional 242 units planned. In generating capability, these plants amount to 213,340 MW(e) in operation and construction and a total of 469,530 MW(e) with those on order and planned. Most advanced industrial states look to nuclear power to provide the mainstay of their electrical generating capacity. For example, projections show in 1985 nuclear energy will account for 50 percent of the electrical capacity in France; 38 percent in Belgium; 20 percent in the United Kingdom; and 17 percent in Japan. Additionally, nine nations currently operate or plan reprocessing capability and seven of these also operate or have plans for breeder reactor programs.[8]

The United States has consistently informed the world community of the need to rely on fuels other than oil to meet the energy needs of future economic growth. The Declaration at the conclusion of the 1978 Bonn

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[8] Reprocessing: Belgium; Brazil; France; India; Italy; Japan; Sweden; United Kingdom; and West Germany. Breeder: USSR; United Kingdom; France; Federal Republic of Germany; Japan; Italy; and India. Source: Joint Committee Print: Nuclear Proliferation Factbook, September, 1980.

Economic Summit Conference, signed by President Carter and the leaders of the Western Nations, stated that: "The further development of nuclear energy is indispensable, and the slippage in the execution of nuclear power programs must be reversed."

Again at the 1980 Venice Economic Summit, the United States signed the communique which stated: "We underline the vital contribution of nuclear power to a more secure energy supply. The role of nuclear energy has to be increased if world energy needs are to be met." Unfortunately, the Carter Administration was perceived internationally, because of attempts to slow world reprocessing and breeder reactor development, as severely hampering the growth of nuclear power.

Strong international disagreement with the Carter policy has left the United States in a somewhat isolated position with a substantial loss of prestige and influence in the peaceful uses of nuclear energy. Our influence in non-proliferation matters thus is not as strong as previously.

During the period 1970 to 1973, United States companies captured 86 percent of the nuclear reactor capacity exported to the free world, but this share has now declined to 43 percent.

Reactor orders are often only the tip of a massive package which includes reactors; components; uranium; enrichment and fabrication services; technology transfers; and training. Industry sources note the value of an exported nuclear power plant can exceed $500 million and related manpower is approximately 15,000 man-years of direct, and an amount of indirect, U.S. employment, spread over a 6 to 7 year period. Losses in potential U.S. sales since 1975 are estimated by the industry to reach $9 billion.

Additionally, the value of European reprocessing contracts over the next decade, including transport charges, is expected to amount to almost $3 billion.

In each instance, loss of U.S. participation in the market can be readily equated with loss of economic benefits, but also loss of influence over the direction of those national nuclear programs.

## III. Impact of Licensing Delays on the U.S. Electrical Generating Capacity

As indicated by the GAO in a study of "Electric Power Plant Cancellation and Delays",[9] the U.S. electric utility industry has cancelled plans for 184 generating units (80 nuclear and 84 coal-fired plants) from 1974 to 1978 -- almost as many units as were put into operation during the same period.

Of the 184 new power plants that were brought on-line between 1974 and 1978, 79 percent of them experienced delays roughly from under 6 months for 41 plants to 3 years or more for 23 plants. Eighty-one percent of the 330 new power plants projected to be completed by the early 1990's have already been delayed an average of 40 months. Average delays for nuclear units are the highest amongst fuel types, averaging 52.7 months of delay per plant.

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[9] GAO Report to the Congress of the United States, EMD-81-25, December 1980.

"Continued cancellations and delays may contribute to increased oil consumption, greater dependence on foreign oil, greater potential for electrical service interruptions and higher electricity rates for consumers", the GAO report found.

In the nuclear area, we have found that the Nuclear Regulatory Commission has become so bogged down in its regulatory process its licensing operations have come to a virtual standstill. For plants scheduled to be brought into commercial operation in 1981-1982:

- construction will have been completed on 13 plants a total of 90 months before operating licenses will be issued;

- the cost increases to utilities and their ratepayers associated with these delays is already between $2 and $3 billion and growing each day. In other words, each month of delay adds $30-40 million to the cost of a typical generating station;

- due to these delays, the electric utilities constructing these plants will, according to DoE, consume 42 million barrels of oil more than they might have otherwise consumed.

The impact of rapidly escalating oil costs, the cost of capital and escalating construction costs, exacerbated by licensing delays, have dealt a devastating blow to the financial capability of the utility industry. There is no doubt that this is the most serious issue influencing the adequacy and reliability of electric power supply in the 1980's and beyond.

It is to be hoped that this Committee and the Congress will pay early attention to the need for a streamlining of the regulatory process related to the construction and licensing of electrical generating capacity, both nuclear and coal-fired.

## IV. Nuclear Power Budget

The Carter Administration virtually brought to a halt work to close the back end of the fuel cycle. As shown, from the standpoint of domestic economics, national security and international prestige, the Reagan budget must reflect the recognition that coal and nuclear power are the only economic alternatives for large-scale application in the remainder of the century.

A review of the nuclear budget over the past several years clearly shows that in relation to the overall DoE budget and the funding afforded other energy research, development and demonstration programs, nuclear program funding has declined. According to Attachment 3, appended to my testimony, the nuclear fission budget has declined by 15.4 percent since 1977 in terms of year of budget dollars. In real terms, taking inflation into account, the reduction of nuclear funding is even more dramatic, amounting to a 42 percent reduction in constant FY81 dollars.

The ever vigilant anti-nuclear forces have adopted the strategy for FY82 of attacking the nuclear energy budget by projecting it as a disproportionate share of the total DoE budget. This is accomplished by adding to the nuclear energy total, funding for military applications, nuclear science applications and the uranium enrichment program. Clearly military and science applications have no bearing on the nuclear energy component. Nor should uranium enrichment program funding be included because the program is operated, as required by law, on a 10-year campaign full-cost recovery basis.

The nuclear energy component of President Carter's FY82 Budget for DoE amounts to $959 million. Even this amount for nuclear funding includes costs incurred by the government for the commercial waste management and spent fuel storage programs which will be returned in the form of fees paid by the utilities for the utilization of such services once the programs have become operational.

The $959 million represents only six percent of the total DoE Budget of $16.5 billion and 17 percent of the Conservation and Energy Research and Development sectors. The nuclear budget must be increased if the downward trend in nuclear program funding is to be turned around and if nuclear power is to contribute its full potential to establishing energy security for the United States.

ATTACHMENT 3
1990 Price FOB Plant

| Technology | 1978 $ Per Conventional Unit | 1978 $ Per Barrel | 1990 Delivered Cost Of Residential Space Heat (1978 $ Per Billion Btu) | Basis For Economic Estimates |
|---|---|---|---|---|
| Liquids: | | | | |
| Enhanced Oil Recovery | 10 to 35 per barrel | 10 to 35 | 6 to 14 | Field Tests |
| Oil Shale | 15 to 30 per barrel | 15 to 30 | 8 to 13 | Prelim. Designs |
| Coal Liquids | 25 to 35 per barrel | 25 to 35 | 11 to 14 | Concep. Designs |
| Gases: | | | | |
| Unconventional Gas | 2.50 to 5.00 per billion Btu | 15 to 30 | 9 to 14 | Various |
| High Btu Gas from Coal | 3.75 to 4.50 per billion Btu | 20 to 25 | 11 to 13 | Prelim. Designs |
| Low-medium Btu Gas from Coal | 2.50 to 4.00 per billion Btu | 15 to 25 | NA | Do. |
| Electricity: | | | | |
| Light Water Reactors | 25 to 35 mils per kilowatt hour | 40 to 60 | 12 to 15 | Construction |
| Breeder Reactors | NA | NA | NA | NA |
| Coal with FGD | 25 to 40 mils per kilowatt hour | 40 to 70 | 12 to 17 | Construction |
| AFB/PFB (utility only) | 25 to 40 mils per kilowat hour | 40 to 17 | 12 to 17 | Concep. Designs |
| Combined cycle with gasifier | 30 to 45 mils per kilowatt hour | 50 to 75 | 14 to 18 | Do. |
| Fuel cell (coal fueled) | NA | NA | NA | NA |
| MHD | NA | NA | NA | NA |
| Hydrothermal geothermal | 30 to 60 mils per kilowatt hour | 50 to 100 | 16 to 23 | Prelim. Designs |
| Hydro low head | 20 to 60 mils per kilowatt hour | 35 to 100 | 10 to 23 | Construction |
| Wind (large and small) | 55 to 80 mils per kilowatt hour | 95 to 135 | 21 to 29 | Concep. Designs |
| Photovoltaics[1] | 100 to 140 mils per kilowatt hour | 170 to 240 | 36 to 48 | Program goals |
| Solar Thermal[1] | 60 to 100 mils per kilowat hour | 100 to 170 | 23 to 36 | Do. |
| OTEC[1] | 50 to 100 mils per kilowat hour | 85 to 170 | 20 to 36 | Do. |
| Space power systems | NA | NA | NA | NA |
| Fusion | NA | NA | NA | NA |
| Biomass | 45 to 60 mils per kilowatt hour | 75 to 100 | 18 to 23 | Construction |

1. Intermediate high cost applications in 1990. Later application projected to have lower cost.

ATTACHMENT 2

July 24, 1980

SCIENTISTS AND ENGINEERS FOR SECURE ENERGY
and
THE HOOVER INSTITUTION

## STATEMENT OF COLLOQUIUM

## CONTINGENCY PLANNING FOR AN ENERGY EMERGENCY

A sense of urgency permeated a meeting of 60 of the nation's leading academicians and industrialists concerned with energy problems, convened June 16-18 at Stanford University. Entitled "Contingency Planning for an Energy Emergency", the colloquium dealt with the consequences of a sudden cut-off of oil from the Persian Gulf.

The prolonged interruption of oil supplies from the Gulf by any one of a number of scenarios (for example: revolution or Soviet expansionism) is a real possibility. There was nearly unanimous agreement that the economy of the United States and of its allies would be in jeopardy if this occurred, and that immediate programs to reduce this vulnerability should be instituted.

The colloquium was sponsored by Scientists and Engineers for Secure Energy and by the Hoover Institution. The participants considered how the energy requirements of the United States could be met if the contingency occurred. The physical limits of a national response covering a period of five years from the cut-off were investigated. Topics discussed included: emergency conservation measures; possible expansion of oil supplies from alternate sources; substitution, when possible, of gas, coal and electricity for oil; effects on electric power generation; rationing and other forms of allocation; economic effects and changes in life style; and advance preparations to reduce our vulnerability.

The colloquium findings are:

The initial situation faced by the industrial democracies after a complete cut-off (which is a limiting case of more probable partial cut-offs) would be a short-fall of about 45% of their oil supplies, or 16 million barrels/day. According to the existing oil-sharing agreements between the U.S. and the other members of the International Energy Agency, the short-fall would be distributed as follows:

- U.S. oil supply would be reduced about 35%, by 6 million barrels/day,
- Oil supply of our allies would be reduced about 55%, by 10 million barrels/day.

As a result, in the United States a Mideast cut-off would:

- cause the transportation system to be greatly disrupted. Private automobile use would be reduced about 50%, and other vehicle transportation would be cut about 30%;
- cause massive additional unemployment of over 8 million workers, and reduce annual disposable income by over $3,000 per household;
- impair our ability to mobilize effectively to defend ourselves, and imperil the security of the free world;
- lower the Gross National Product by $350-650 billion dollars per year (about 15 to 25%).

Further,

- depending on the timing of the cut-off and the region of the country, one could expect the closing off of some housing space, or abandonment of some types of housing which the users might not be able to heat; accelerated movement of people to a warmer climate; relocation of people closer to their places of work; and perhaps even dormitory housing for younger workers near industrial enterprises (as occurred, for example, at Oak Ridge during World War II);
- shopping habits would undergo dramatic changes, and recreational and cultural activities would be greatly curtailed.

In the five years subsequent to an oil cut-off, assuming only present technologies could be effective on a large-scale, replacement of the U.S. oil supply deficit by determined expansion of domestic and other foreign oil supplies, and by substitution of other fuels, would be substantial but still only partial (40-60%).

To avoid the vulnerability of our society to these consequences, participants recommended a number of measures. While further measures may be necessary or advisable, there was general agreement that the following should be adopted:

1. The security of the United States requires the implementation of an aggressive program to increase both energy production and the more efficient use of oil. The object of this program should be to reduce vulnerability to loss of imported oil as quickly as possible. Examples of opportunities for increased sources of energy supply are: coal, gas, nuclear power, biomass, and on a longer time scale, shale oil. As was proven during World War II, high level policy organization is an absolute

prerequisite for organizing and implementing an effective program.

2. Rapid decontrol of oil and gas prices and abolition of entitlements are the most important ways of providing needed incentives to displace oil imports by inducing real conservation and increasing supply. Equity concerns, such as undue burdens on people with low incomes, should be dealt with by income transfers rather than by manipulating prices or by allocations.

3. Environmental laws should be administered and perhaps amended to encourage energy production as well as to protect the environment, thus reducing the danger that curtailments caused by an oil cut-off will harm the health and welfare of the American people.

4. Licensing for operation of completed nuclear plants should be expedited in order that the plants may be put in production immediately. Partially completed power plants (both coal and nuclear) should be completed on an accelerated schedule. Unnecessary regulatory impediments to other energy facilities (such as pipe-lines, port facilities and drilling platforms) should be removed.

5. Oil for non-transportation uses should be replaced by natural gas and coal- and nuclear- generated electricity as soon as possible. Limitations on production and use of natural gas

and electricity should be reduced to permit price competition to determine their relative market shares. Electric utility rates should more nearly reflect the marginal costs of new power plants.

6. The energy industries should with government encouragement jointly prepare emergency plans against an oil cut-off. Among other measures, acquiring spare production and storage capacity should be encouraged.

7. The automotive industries should be encouraged to increase their efforts to produce more fuel efficient automobiles, including electrical and hybrid vehicles.

8. Contingency plans should be made to curtail energy consumption, and to suspend temporarily some procedural requirements and environmental standards, in the event of an oil cut-off. Wide public discussion of these plans at the community and the factory levels should be inaugurated.

9. In addition to our present commercial operational oil reserve (about 30-40 days of total imports), we should begin to fill the Strategic Petroleum Reserve at a rate of more than 300,000 bbl/day. Note that at a rate of 100,000 bbl/day, it would take 20 years to accumulate an amount of oil which would cover the maximum projected deficit (6 million bbl/day) for four months. To the extent possible, the SPR fill should be achieved by reduction of current oil consumption according to the preceding recommendations.

10. Since the use of oil in Western Europe and Japan for generating electricity is about 3 million barrels per day, it is in our mutual interest to reduce their vulnerability by encouraging and assisting their conversion to nuclear energy and coal.

Implementing the foregoing recommendations would, as time passes, progressively reduce the severity of the initial shock of an oil cut-off and the duration of the recovery period.

The undersigned participants subscribe to the general sense of the above statement as individuals (affiliation for identification only):

## SIGNATORIES AS OF JULY 24/1980

| | |
|---|---|
| Robert K. Adair | Yale University |
| Donald G. Allen | New England Electric Co. (ret.) |
| Hans A. Bethe | Cornell University |
| Elliot Bloom | Stanford Linear Accelerator Center |
| Harvey Brooks | Harvard University |
| Arthur M. Bueche | General Electric Company |
| Toby Burnett | Westinghouse Electric Corporation |
| Peter Camp | General Electric Company |
| Roger S. Carlsmith | Oak Ridge National Laboratory |
| Karl Cohen | Stanford University |
| Thomas Connolly | Stanford University |
| Gordon R. Corey | Commonwealth Edison Co. (ret.) |
| W. Kenneth Davis | Bechtel Power Corporation |
| R. Leslie Dugan | $SE_2$ |
| Lloyd E. Elkins | Petroleum Consultant, Tulsa, OK |
| Robert Erdmann | Science Applications, Inc. |
| Gary J. Feldman | Stanford Linear Accelerator Center |
| John S. Foster, Jr. | TRW, Inc. |
| Michehl R. Gent | National Electric Reliability Council |
| Tsahi Gozani | Science Applications, Inc. |

| | |
|---|---|
| Elmer E. Hall | Pacific Gas & Electric Co. |
| Carl E. Hedeen | General Motors Corporation (ret.) |
| Carolyn Meinel Henson | L5 Society |
| Frederick A. L. Holloway | Treasurer, National Academy of Engineering |
| Richard J. Kessler | Center for Strategic and International Studies |
| George Marotta | Hoover Institution |
| Sullivan S. Marsden, Jr. | Stanford University |
| John McCarthy | Stanford University |
| Robert R. Nathan | Consulting Economist, Washington, D.C. |
| Kenneth D. Nichols | U.S. Army (ret.) |
| W. E. Parkins | Rockwell International |
| Norman Parlee | Stanford University |
| S. S. Penner | University of California at San Diego |
| Robert B. Richards | General Electric Company |
| Larry E. Ruff | Brookhaven National Laboratory |
| Andrew Safir | Business & Transportation Agency, State of California |
| Benjamin Schlesinger | American Gas Association |
| Herman E. Schroeder | E.I. DuPont de Nemours & Co. (ret.) |
| Paul Seabury | University of California at Berkeley |
| Frederick Seitz | Rockefeller University |
| Rudolf Sher | Stanford University |
| George P. Shultz | The Bechtel Group |
| Chauncey Starr | Electric Power Research Institute |
| John S. Taylor | Westinghouse Corporation |
| Edward Teller | Hoover Institution |
| Miro M. Todorovich | City University of New York |
| Robert K. Whitford | Purdue University |
| Eugene P. Wigner | Princeton University |
| Bertram Wolfe | General Electric Company |
| Charles A. Zraket | The Mitre Corporation |

ATTACHMENT 3

## ERDA/DOE TOTAL BUDGET AUTHORITY
(Millions of Dollars)

| 1977 | 1978 | 1979 | 1980 | 1981 | Inc. Thru. FY81 Year Of Budget Dollars | Constant FY81 Dollars |
|---|---|---|---|---|---|---|
| | | | | | 7,205 | 4,240.5 |
| 6,389 | 10,283 | 10,799 | 11,675 | 13,594 | 112.8% | 45.3% |

## ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION

| 1977 | 1978 | 1979 | 1980 | 1981 | Inc. Thru. FY81 Year Of Budget Dollars | Constant FY81 Dollars |
|---|---|---|---|---|---|---|
| | | | | | 947 | -449.6 |
| 3,010 | 2,696 | 3,625 | 3,730 | 3,957 | 31.5% | -10.2% |

## CONSERVATION RESEARCH AND DEVELOPMENT

| 1977 | 1978 | 1979 | 1980 | 1981 | Inc. Thru. FY81 Year Of Budget Dollars | Constant FY81 Dollars |
|---|---|---|---|---|---|---|
| | | | | | 656.1 | 581.44 |
| 160.9 | 692 | 671 | 815 | 817 | 407.8% | 246.8% |

## FOSSIL ENERGY DEVELOPMENT

| 1977 | 1978 | 1979 | 1980 | 1981 | Inc. Thru. FY81 Year Of Budget Dollars | Constant FY81 Dollars |
|---|---|---|---|---|---|---|
| | | | | | 647.8 | 423.59 |
| 483.2 | 702 | 791 | 897 | 1,131 | 134.1% | 59.9% |

## SOLAR ENERGY DEVELOPMENT

| 1977 | 1978 | 1979 | 1980 | 1981 | Inc. Thru. FY81 Year Of Budget Dollars | Constant FY81 Dollars |
|---|---|---|---|---|---|---|
| | | | | | 285.6 | 150.9 |
| 290.4 | 303.0 | 528 | 602 | 576 | 98.3% | 35.5% |

## GEOTHERMAL ENERGY DEVELOPMENT

| 1977 | 1978 | 1979 | 1980 | 1981 | Inc. Thru. FY81 Year Of Budget Dollars | Constant FY81 Dollars |
|---|---|---|---|---|---|---|
| | | 130 | | | 144.3 | 64.2 |
| 54.7 | 106 | | 145 | 199 | 263.8% | 148.4% |

NUCLEAR FISSION

| 1977 | 1978 | 1979 | 1980 | 1981 | Inc. Thru. FY81 Year Of Budget Dollars | Constant FY81 Dollars |
|---|---|---|---|---|---|---|
| | | | | | -181.7 | 730.93 |
| 1,183.7 | 1,062 | 1,204 | 1,182 | 1,002 | -15.4% | -42% |

FUSION POWER RESEARCH AND DEVELOPMENT

| 1977 | 1978 | 1979 | 1980 | 1981 | Inc. Thru. FY81 Year Of Budget Dollars | Constant FY81 Dollars |
|---|---|---|---|---|---|---|
| | | | | | -21.9 | 214.9 |
| 415.9 | 325 | 356 | 356 | 394 | -5.3% | -35.3% |

Mrs. BOUQUARD. John, please proceed with your testimony.

Before we begin I would like to recognize Mr. Billy Cooper, a distinguished gentlemen from Tennessee, who is with us today. Welcome to our hearing. We are glad to have you with us.

Mr. Kearney, proceed.

## STATEMENT OF JOHN J. KEARNEY, SENIOR VICE PRESIDENT, EDISON ELECTRIC INSTITUTE

Mr. KEARNEY. Thank you, Madam Chairman.

Like Mr. Conway, I would appreciate it if my statement, which represents the views of both the Edison Electric Institute, which is the national association of electric utilities companies, and the American Nuclear Energy Council, which represents more than 100 organizations having an interest in nuclear power, could be submitted for the record.

Mrs. BOUQUARD. Without objection it will be made a part of the record.

Mr. KEARNEY. What I would like to do with the remainder of my time is highlight some of the points that we made in our statement.

As you know, the new administration's budget for fiscal 1982 has not been available for our review and while this puts us at a disadvantage in not allowing us a chance to study the DOE proposals and give our opinion as to the adequate funding levels, we are prepared to present our views on some of these programs and would offer to provide industry input for your deliberation in evaluating the budget when it is made available.

My prepared statement presents, in our opinion, a compelling case for the need of nuclear power for the well-being of the Nation. I think one important aspect of getting on with the job of nuclear power development is to continue research programs in this area by the Federal Government which are necessary to provide and promote this shift to nuclear power, that we feel is essential for the well-being of the country.

You have recently obtained industry testimony on nuclear programs from a number of persons on nuclear waste management, gas-cooled reactors, breeder reactors, and the back end of the nuclear fuel cycle. I would just like to make periodic reference to these earlier testimonies and will highlight some of the most important specific elements.

Specifically, I would like to address the following programs:

Regionally sited away-from-reactor (AFR) spent fuel storage facilities.

Spent fuel reprocessing.

Commercial nuclear waste management.

Breeder reactors.

Gas-cooled reactors.

Uranium enrichment.

Nuclear safety.

All topics and programs and facilities that we think are necessary for a very viable nuclear power program in this country.

In our judgment, Congress should provide the authority for DOE to acquire or construct regionally sited AFR spent-fuel storage facilities and establish a funding arrangement such that DOE can provide spent-fuel storage.

The most recent DOE studies on the need for AFR's has shown that AFR capacity is required during the 1990's. Utilities have been and are continuing to rerack their storage pools at reactors to provide maximum onsite storage and to use intrautility transshipment where permitted. But in spite of this the most recent DOE studies indicate a need for AFR's during the 1980's.

There were initiatives in the 96th Congress for an AFR program which were supported by the industry and we concur that the acquisition of existing AFR facilities is essential to serve these early needs.

As you know, the need for this resulted from the prior administration's change in direction with its 1977 declaration of an indefinite postponement of commercial reprocessing. This action of the prior administration actually trapped the utilities industry in an unfortunate position of having committed billions of dollars for nuclear generation facilities with limited onsite spent-fuel storage capacity and no reasonable alternative for the disposing of the spent fuel.

During the 1980's, a number of presently operating nuclear power reactors will need to ship their spent fuel to storage facilities away from reactor sites or face plant shutdowns. To assure the continued operation of existing nuclear power reactors, a congressional directive to the Department of Energy is needed to establish interim storage facilities by the mid-1980's.

Mr. OTTINGER. Could I interrupt for a second. I wonder if you can give us more detail on that. Exactly how many plants, how much capacity is in fact going to be needed, and the relative costs of adding the storage capacity to the plant, versus spent fuel being shipped away from a reactor facility?

Mr. KEARNEY. Mr. Ottinger, I can provide that for the record. I do not have that with me, but let me make just one comment on that.

As I indicated in my testimony, the utilities are, to the extent that it is technically feasible, and from the point of view of safety, expanding existing onsite storage facilities.

The other alternative is the AFR's and additional onsite facilities. When you come to the question of additional onsite facilities; as Mr. Conway has pointed out, the licensing uncertainties, the proliferation of change in the licensing aspects have made it a very, very uncertain course of action to consider, opening up the licensing of existing plants to do such work as add to the existing facilities.

In our judgment, and I think it has been shared by the Department of Energy, the proper way to go beyond what is being done onsite is AFR's. But I will provide for you the information you sought.

Mr. OTTINGER. That is a decision we will have to make. We are going to have limited dollars. The question I would like to have addressed: How much capacity is going to be needed and what the cost benefits are of doing AFR's versus adding to the listed onsite facilities.

Mrs. **Bouquard.** If I may interrupt, I think we covered this question in our reprocessing hearings last week when we discussed the Barnwell plant and its capacities and our need by the year 2000 for about four more facilities. The AFR's would certainly be in use by then so we could have this needed capacity; is that correct?

Mr. **Kearney.** Mrs. Bouquard, I think there is available to the staff a recent study by DOE but we will also make certain that whatever material you think is necessary we will have sent to you.

Mr. **Ottinger.** We will need that for our committee as well. We want to make as sound a decision as we can so we appreciate that information.

Thank you, Madam Chairman.

Mr. **Kearney.** We shall comply.

We concur in the early indication by the Secretary of Energy, Mr. Edwards, for the need to resume the reprocessing which was halted by the previous administration. However, I think I would like to make clear that commercial reprocessing could not be made available in sufficient time with adequate capacity to be a substitute for near-term AFR's.

If the Federal ban on reprocessing were to be lifted today, the length of time in building and licensing any facility would still necessitate early AFR's.

I would also like to emphasize that the cost of programs for storage of spent fuel will be paid by the utilities to the Federal Government. These costs in turn will be reflected in the cost of providing electricity generated by nuclear power and ultimately borne by the utilities customers.

The research and development program at the Barnwell nuclear fuel plant in South Carolina in our judgment should be continued and enhanced. We support the statement made before this subcommittee on March 5 by Mr. Colby of the Allied Chemical Corp. by Mr. James Buckham of the Allied General Nuclear Services on the Barnwell program.

During fiscal years 1979-1981 Congress appropriated funds for research and development programs at Barnwell. Direct congressional support for the Barnwell programs came about after the prior administration's April 1977 decision to indefinitely defer commercial reprocessing, the purpose for which Barnwell was originally designed and built.

During this period the programs at Barnwell have preserved the nucleus of its unique technical staff, produced valuable research results on the nuclear fuel cycle and maintained the option of using the Barnwell facility in the future.

Programs at Barnwell have developed what many believe to be the most sophisticated nuclear safeguards system in the world. It is clear, based upon the actions being taken by other countries, and this is quite clear when you read the INFCE report, that reprocessing of spent fuel will be a part of the world's energy future.

Because of this I think it would be folly for this Nation to abandon its technological leadership in this area by not continuing basic research and technical developments in reprocessing.

Also, it is inconsistent with a continuation of the breeder reactor program at any level not to develop the reprocessing capability needed to fuel the breeder reactors.

Additionally, Barnwell provides one of only three existing spent-fuel pools available to implement DOE's AFR spent-fuel storage program which we have just spoken about. Consequently we believe that DOE should, as part of its program to develop the needed multiregional sites, promptly purchase or lease Barnwell as one of these sites to provide AFR spent-fuel storage and continue to support research, development, and demonstration of reprocessing at this unique facility.

The industry generally supports the need for a major DOE program on nuclear waste management that is focused on achieving a waste repository within a reasonable time period. The present research and development programs are expansive beyond reason and a clear direction must be defined.

A step-by-step approach needs to be developed which will result in siting, construction, and operation of a geologic repository. The current schedule for this is, however, unnecessarily relaxed because of the lack of program focus.

For example, during the last 4 years, the timetable for operation of the first geologic repository has slipped by more than a full decade from 1985 to about the year 2000. Utilities accept the responsibility to pay the Federal Government for disposal of nuclear waste, on a full-cost recovery basis, for all reasonable program costs.

In an effort to put the DOE program on a more reasonable schedule, a number of subcommittee members have initiated the Nuclear Waste Research, Development, and Demonstration Act of 1981, H.R. 1909.

Last month Mr. R. Greg Snipes of Duke Power Co. appeared here on behalf of the nuclear industry and presented testimony on that matter. I will not repeat Mr. Snipes' statement, except to reiterate our support for H.R. 1909 provided the early demonstrations are fully integrated into the DOE program so as to assist and not deflect the full-scale repository program.

Madam Chairman, I had the privilege on March 4 to appear before you as one member of an industry panel to present the "Utility Perspective on Achieving the LMFBR Program Goals and Objectives." A uniform position on breeder reactors was presented by the panel and my position of fully supporting a strong LMFBR program in general and the Clinch River breeder reactor specifically is a continuing industry posture.

Breeder reactors represent the only predictable means of serving the long-term electricity needs of the Nation along with the use of coal and the CRBR is the right plant at the right time—let's get on with the job.

The high-temperature gas-cooled reactor (HTGR) concept offers potential for greater operating efficiencies, greater flexibility in reactor siting, and possible application for industrial process heat requirements.

Development of the HTGR continues to be supported both financially and with managerial expertise through the utility-supported Gas-Cooled Reactor Associates (GCRA). We fully support the statement submitted by Mr. Richard F. Walker, president of Public Service Co. of Colorado and chairman of GCRA, on February 26, 1981.

We also urge the Congress to continue its support for the development of gas centrifuge technology for uranium enrichment and the construction of the gas centrifuge enrichment plant (GCEP).

The three DOE gaseous diffusion plants have served the U.S. military and domestic and foreign commercial nuclear power programs well. However, the diffusion plants themselves are highly dependent on large quantities of electric energy.

As you are presently aware, 50 percent of the cost of present uranium enrichment services is the cost of electricity to run the diffusion plants. A gas centrifuge process would use only 4 to 5 percent of the electricity used by the diffusion process to produce a unit of separative work (SWU). Thus the GCEP offers obvious benefits both in conservation of energy resources and in potentially reducing the cost to consumers.

It is also an important element in maintaining our position in the international community as a reliable and competitive supplier of uranium enrichment services.

Again the utilities pay the Federal Government for uranium enrichment service on a full-cost recovery basis.

Nuclear safety is a major element of the Nation's nuclear programs. The utility industry has established the nuclear safety analysis center with a primary function of defining safety improvements in equipment, systems, and plant designs.

The Institute of Nuclear Power Operations was established by the utility industry over a year ago to strive for improved safety in plant operations.

Last year, largely due to this subcommittee's efforts, the 96th Congress produced the Nuclear Safety Research and Development Act of 1980. We generally support the intent of the act and several of its programs.

However, we believe the studies which call for an evaluation of a Federal corps of nuclear operators and a major Federal simulator program are of doubtful value.

Federal considerations of nuclear safety should be pursued in close cooperation with industry efforts.

In conclusion, we would like to point out the electric utility industry is making its own major contributions toward research and development of technologies to improve our ability to supply electricity to our customers.

Economic and reliable electric energy must play an ever-increasing role in this country. This role can only be achieved through the use of nuclear power and coal.

We commend the leadership shown by this subcommittee in supporting the required aggressive research and development effort to assure that safe and environmentally acceptable nuclear energy is available to the Nation's citizens. The electric utility industry supports and stands ready to assist the subcommittee and Congress in its review of the proposed DOE fiscal year 1982 budget.

Madam Chairman, this represents the summary of my statement and Mr. Conway and I will be pleased to respond to questions.

[The prepared statement of Mr. Kearney follows:]

STATEMENT OF

MR. JOHN J. KEARNEY
SENIOR VICE PRESIDENT
EDISON ELECTRIC INSTITUTE

ALSO ON BEHALF OF AMERICAN NUCLEAR ENERGY COUNCIL

ON

U.S. DEPARTMENT OF ENERGY

FISCAL YEAR 1982 NUCLEAR BUDGET

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
SCIENCE AND TECHNOLOGY COMMITTEE
U.S. HOUSE OF REPRESENTATIVES

MARCH 10, 1981

Madam Chairman and Subcommittee Members, I am John J. Kearney, Senior Vice President of Edison Electric Institute, and I am pleased to return before you to discuss the electric utility industry's view of the DOE FY 1982 Nuclear Budget. The Institute is the association of investor-owned electric utilities and its members provide about 78 percent of the nation's electricity, serving over 67 million customers. My testimony today is also on behalf of the American Nuclear Energy Council which represents more than 100 organizations having an interest in nuclear power, including private, public and cooperatively owned utilities, manufacturers, architect-engineers, and various firms in the nuclear fuel cycle.

The new Administration's nuclear budget for Fiscal Year 1982 has not been available for our review. This puts us at a disadvantage of not having a chance to study the DOE proposals and form opinions regarding the adequacy of the funding levels. However, we are prepared to present our views on a number of the programs that should be funded and extend an offer to provide industry input for your deliberations in evaluating the budget.

A primary goal for the nation's energy future should be the early replacement of our demand on the depleting world reserve of petroleum, wherever practical, with the use of our abundant domestic solid fuels--coal and uranium. The best and earliest means of increasing the use of domestic solid fuels is through the increased use of electricity generated by coal and nuclear power plants. Every industry and Federal Government projection of the future energy mix includes a substantial increase in the electricity component. A large portion of the research and development programs of the Federal Government should reflect, permit and promote the goals of shifting from petroleum to solid fuels.

While conservation through greater efficiency in the use of energy must be encouraged and the search for economic alternative fuels be pursued with vigor, we must proceed to improve the use of those technologies that are available and develop those on which we have a high confidence of achieving success. Within the planning horizon of the utility industry, this means the increased use of coal and nuclear fission. Since they have the highest payoff, the Federal Government must support them with appropriate research and development activities. Both coal and nuclear fission must be used to achieve the desired high degree of overall reliability for the electricity supply system as we build new plants to serve the growing economy, displace the use of petroleum and replace obsolete facilities.

You have recently obtained industry testimony on nuclear programs from a number of persons on nuclear waste management, gas-cooled reactors, breeder reactors, and the back end of the nuclear fuel cycle. I will make periodic reference to these earlier testimonies and will highlight some of the most important specific elements.

As you know, nuclear power is -- and will continue to be for many years to come -- a vital part of this nation's energy resources. Presently, some 11 to 12 percent of our total national output of electricity comes from nuclear power. Today nuclear generating capacity, some 50,000 MWe, exceeds the entire installed electric capacity as it existed in this country just 35 years ago. In addition to the some 70 operating nuclear plants, some 90 additional facilities have construction permits from the NRC. When completed, these will add about 100,000 MWe of generating capacity, which will result in generation from nuclear of about 30 percent of the national total. Nuclear power already is providing over 50 percent of the electricity in some areas of the country.

The reliance on nuclear power has provided major benefits to the customers of electric utilities in terms of lower cost of generation, diversity of fuel resources, and decreased reliance on imported foreign oil. When the nuclear power plants currently under construction or on order are completed, these plants, together with the plants in operation, can provide the energy equivalent of more than 4.5 million barrels of oil per day. To achieve these benefits at an early date, however, it will be necessary to reaffirm a national policy that is fully supportive of nuclear power, regain the research and development momentum that was lost during the prior Administration, and remove the regulatory uncertainties and delays now being experienced. The programs and their funding levels in the DOE nuclear budget must reflect the important role that nuclear power is to play in our energy future. Since nuclear and coal are the only near-term options for providing significant quantities of new electric generating capacity, the programs in the DOE FY 1982 budget should be supportive of commercial nuclear power. This is the time to clearly focus the nuclear fission research and development programs to achieve the needed support. There must be a strong commitment to this research and development if today's energy picture is to be improved.

I will now address those programs we believe should receive substantial support in the DOE FY 1982 nuclear budget. They include:

- Regionally-sited away-from-reactor (AFR) spent fuel storage facilities
- Spent fuel reprocessing
- Commercial nuclear waste management
- Breeder reactors
- Gas-cooled reactors

- Uranium enrichment
- Nuclear safety

Away-From-Reactor (AFR) Spent Fuel Storage

Congress should provide the authority for DOE to acquire or construct regionally-sited AFR spent fuel storage facilities and establish a funding arrangement such that DOE can provide spent fuel storage. The most recent DOE studies on the need for AFRs has shown that AFR capacity is required during the 1980s. Utilities have been and are continuing to rerack their storage pools at reactors to provide maximum on site storage and to use intra-utility transhipment where permitted. DOE recognizes the important need for a full core reserve capability at each reactor to provide operational flexibility and assure the availability of the plant; we agree.

Initiatives in the 96th Congress for an AFR program were supported by the industry and we concur that the acquisition of existing AFR facilities is essential to serve the early needs. While it is true that the more recent DOE studies show the needed capacity to be less than previous studies, the need does exist and early Congressional authority is essential for an AFR program.

For two decades prior to 1977, the Federal Government and the nuclear industry based their programs on the approach of recovering by reprocessing the energy values contained in spent fuel. However, the prior Administration changed that direction with its April 1977 declaration of an indefinite deferral of commercial reprocessing. This action of the prior Administration trapped the electric utility industry in the unfortunate position of having committed billions of dollars for nuclear generating facilities with limited on-site spent fuel storage capability and no reasonable alternative for disposing of the spent fuel. The industry fully recognizes that spent fuel represents a large national energy resource that should be used. Unfortunately, the direction for its use has been clouded by the Federal Government and a reasonable interim program has not been put in place to compensate for this Federal action. Thus, during the 1980s a number of presently operating nuclear power plants will need to ship their spent fuel to a storage facility away from the reactor site or face plant shutdowns. To assure the continued operation of existing nuclear power reactors a Congressional directive to the Department of Energy is needed to establish interim storage facilities by the mid 1980s. A fixed date and location for at least the first one or two such facilities is needed to assure the availability of the storage capacity and the first facilities should employ the proven technology of underwater pool storage.

We concur with the early indications by Secretary of Energy James B. Edwards for the need to resume the reprocessing programs halted by the prior Administration and this Subcommittee may share this desire. However, I must point out that commercial reprocessing could not be made available in sufficient time, with adaquate capacity to be a substitute for the needed early AFRs. If the Federal ban on reprocessing were to be lifted today, the lengthy time of building and licensing any facility would still necessitate these early AFRs. We fully support DOE efforts in the development of dry, monitored and retrievable storage approaches as potential lower cost means of storage if follow-on-facilities are needed.

I should emphasize that the cost of programs for storage of spent fuel will be paid by the utilities to the Federal Government. These costs in turn will be reflected in the costs of providing electricity generated by nuclear power and ultimately borne by the utilities' customers. The implementation of DOE's AFR program will remove one of the uncertainties surrounding nuclear power.

Spent Fuel Reprocessing

The research and development program at the Barnwell Nuclear Fuel Plant in South Carolina should be continued and enhanced. We support the statement made before the Subcommittee on March 5, 1981 by Mr. L. James Colby, Jr. of Allied Chemical Corporation and Mr. James A. Buckham of Allied General-Nuclear Services on the Barnwell Program.

During fiscal years 1979-1981 Congress appropriated funds for research and development programs at Barnwell. Direct Congressional support for the Barnwell programs came about after the prior Administration's April 1977 decision to indefinitely defer commercial reprocessing, the purpose for which Barnwell was originally designed and built. During this period the programs at Barnwell have preserved the nucleus of its unique technical staff, produced valuable research results on the nuclear fuel cycle and maintained the option of using the Barnwell facility in the future. Programs at Barnwell have developed what many believe to be the most sophisticated nuclear safeguards system in the world. It is clear, based upon the actions being taken by other countries, that reprocessing of spent fuel will be a part of the world's energy future. It would be folly for this nation to abdicate its technological leadership in this area by not continuing basic research and technical developments in reprocessing. Also, it is inconsistent with a continuation of the breeder reactor program at any level not to develop the reprocessing capability needed to fuel the breeder reactors. We look forward to a re-instatement of commercial reprocessing early during President Reagan's Administration. The work being continued at Barnwell will be enormously valuable when that occurs.

Additionally, Barnwell provides one of only three existing spent fuel pools available to implement DOE's AFR spent fuel storage program. DOE should, as part of its program to develop the needed multi-regional sites, promptly purchase or lease Barnwell as one of these sites to provide AFR spent fuel storage and continue to support research, development and demonstration of reprocessing at this unique facility.

## Commercial Nuclear Waste Management

The industry generally supports the need for a major DOE program on nuclear waste management that is focused on achieving a waste repository within a reasonable time period. The present research and development programs are expansive beyond reason and a clear direction must be defined. A step-by-step approach needs to be developed which will result in siting, construction and operation of a geologic repository. The current schedule for this is, however, unnecessarily relaxed because of the lack of program focus. During the last four years, the timetable for operation of the first geologic repository has slipped by more than a full decade from 1985 to about the year 2000. Utilities accept the responsibility to pay the Federal Government for disposal of nuclear waste, on a full cost recovery basis, for all reasonable program costs.

In an effort to put the DOE program on a more reasonable schedule, a number of Subcommittee Members have initiated the Nuclear Waste Research, Development and Demonstration Act of 1981, H.R. 1909. On February 26, 1981, Mr. R. Greg Snipes of Duke Power Company appeared here on behalf of the nuclear industry and presented testimony on that matter. I will not repeat Mr. Snipes' statement, except to reiterate our support for H.R. 1909 provided the early demonstrations are fully integrated into the DOE program so as to assist and not deflect the full-scale repository program.

## Breeder Reactors

Madam Chairman, I had the priviledge on March 4th, to appear before you, as one member of an industry panel, to present the "Utility Perspective on Achieving the LMFBR Program Goals and Objectives." A uniform position on breeder reactors was presented by the panel and my position of fully supporting a strong LMFBR Program in general and the Clinch River Breeder Reactor specifically is a continuing industry posture. Breeder reactors represent the only predictable means of serving the long-term electricity needs of the nation along with the use of coal and the CRBR is the right plant at the right time - let's get on with the job.

## Gas-Cooled Reactors

The high temperature gas-cooled reactor (HTGR) concept offers potential for greater operating efficiencies, greater flexibility in reactor siting, and possible application for industrial process heat requirements. Development of the HTGR continues to be supported both financially and with managerial expertise through the utility supported Gas Cooled Reactor Associates(GCRA). We fully support the statement submitted by Mr. Richard F. Walker, President of Public Service Company of Colorado and Chairman of GCRA, on February 26, 1981.

## Uranium Enrichment

We urge the Congress to continue its support for the development of gas centrifuge technology for uranium enrichment and the construction of the Gas Centrifuge Enrichmant Plant (GCEP). The three DOE gaseous diffusion plants have served the U.S. military and domestic and foreign commecial nuclear power programs well. However, the diffusion plants themselves are highly dependent on large quantities of electric energy. Fifty percent of the cost of present uranium enrichment services is the cost of electricity to run the diffusion plants. A gas centrifuge process would use only 4 to 5 percent of the electricity used by the diffusion process to produce a unit of separative work (SWU). The GCEP offers obvious benefits both in conservation of energy resources and in potentially reducing the cost to consumers. It is also an important element in maintaining our position in the international community as a reliable and competitive supplier of uranium enrichment services.

The recent report by the DOE Energy Research Advisory Board indicated support for the initial phase of GCEP and encouraged the development of advanced isotope separation (AIS) techniques. We encourage the development of AIS techniques which may one day provide an even more efficient form of uranium enrichment. We caution, however, that AIS research and development should not detract from GCEP manufacturing, construction and installation aimed at meeting its present schedule of 2.2 million SWU by 1988 and subsequent increments at Portsmouth, Ohio to a capacity of 8.8 million SWU. The GCEP offers a high confidence path for more efficient uranium enrichment while AIS requires major developmental efforts to apply the technology.

Utilities pay the Federal Government for uranium enrichment service on a full cost recovery basis.

Nuclear Safety

Nuclear safety is a major element of the nation's nuclear programs. The utility industry has established the Nuclear Safety Analysis Center with a primary function of defining safety improvements in equipment, systems and plant designs. The Institute of Nuclear Power Operations was established by the utility industry over a year ago to strive for improved safety in plant operations.

Largely due to this Subcommittee efforts, the 96th Congress produced the Nuclear Safety Research and Developemnt Act of 1980. We generally support the intent of the Act and several of its programs. However, we believe the studies which call for an evaluation of a federal corps of nuclear operators and a major federal simulator program are of doubtful value.

Federal considerations of nuclear safety should be pursued in close cooperation with industry efforts.

In conclusion, the electric utility industry is making its own major contributions towards research and development of technologies to improve our ability to supply electricity to our customers. Economic and reliable electric energy must play an even greater role in this country. This role can only be achieved through the use of nuclear power and coal. We commend the leadership shown by this Subcommittee in supporting the required aggressive research and development effort to assure that safe and environmentally acceptable nuclear energy is available to the Nation's citizens. The electric utility industry stands ready to assist the Subcommittee and Congress in its review of the proposed DOE FY 1982 nuclear budget.

Madam Chairman, it is always an honor and a pleasure to come before you and the Subcommittee to discuss our industry's position on these and related matters. I would be pleased to answer any questions you and the Subcommittee members may have.

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Mrs. **Bouquard**. Thank you very much, Mr. Kearney. This is a day that I personally have been looking forward to.

Our next witness is the Honorable Mike McCormack who all of us know was the former chairman of this subcommittee. We appreciate "Mike" for his knowledge, for his ability and for his in-depth perspective of the energy needs of our country and certainly for his perseverance in the face of opposition to always stand up for technology that he perceives as being vital to our country's energy independence.

So Mike, we are all very happy to have you with us today.

I recognize the gentleman from California.

Mr. **Goldwater**. I want to join you in welcoming Mike to our committee. It is kind of ironic that Mike is sitting on the other side of the table, but in retrospect, maybe that is appropriate.

I think it has been very fortunate that we have someone who has been on all sides of this energy business, actually working in the facilities in the State of Washington and other places and then for so many years in the Congress helping to direct and develop and mold the programs which we are now talking about and then to be back again on the other side with that kind of perspective. I think Mike gives us a resource that you really can't put a dollar figure on, but one which I think we will grow to appreciate. Mike, this is the contribution that you made and I know over the past years in working with you I always found you to have a tremendous bipartisan balanced, and a particularily balanced perspective on the whole question of energy.

So I think we all look forward to listening to your comments and working with you in the next several months as we develop this budget.

Mrs. **Bouquard**. Mr. Ottinger.

Mr. **Ottinger**. I would also like to commend Mr. McCormack as a witness. While we have long been jousting on the question of nuclear energy, Mike McCormack is one of the most dedicated people in the country in trying to make us energy-independent and that includes his efforts on the Photovoltaic Act, Electric Car Vehicles Act, and many other initiatives. I try to achieve that end also.

I do hope, Mike, you will continue to press on a broad front and help us preserve some kind of balance on the program in the nuclear field. We certainly welcome you and are pleased to continue to have your advice on this side of the table and we welcome you here this morning.

Ms. **Bouquard**. Mike, you may proceed.

## STATEMENT OF HON. MIKE McCORMACK

Mr. **McCormack**. Thank you, Madam Chairman. Good morning, Marilyn and Dick and Barry.

I am indeed pleased to have this opportunity to return to the subcommittee, even if it is to this side of the witness table, and to share with you some thoughts and ideas I have relating to our Nation's energy programs and policies—and to your primary arena of responsibility—nuclear energy. Madam Chairman, I have submitted a prepared statement for the record. May I speak informally from it?

Mrs. **Bouquard**. Without objection your written testimony will be included in the record.

Mr. **McCormack**. Thank you, Madam Chairman.

In a very real sense I'm appearing before you in the confidence that this subcommittee will continue the traditions that we have established in the past—traditions of strength, courage, and dedication to serve the Congress and the country well—and, as part of such traditions, an insistence on truth, a realistic perspective, and the application of commonsense.

I know, Madam Chairman, that you will provide the strength and wisdom and leadership to insure that the subcommittee will meet these challenges—and I congratulate you on your chairmanship.

Mrs. **Bouquard**. Thank you very much and I will try to follow your distinguished leadership.

Mr. **McCormack**. Thank you. I certainly will be available to be of assistance to the committee or its members in any way I can.

My testimony today is set against the same background that has motivated the Science and Technology Committee's energy activities for 8 years—the critical need for this Nation to develop economically competitive, environmentally acceptable, practical technologies for producing significant amounts of energy from realistic domestic sources.

The basic facts of the energy crisis will continue to hang a Sword of Damocles over our heads until we eliminate our dependence on imported oil; and we will make little progress in that direction until we come to terms with the fact that even if we are extraordinarily successful with spartan conservation programs, we must approximately double our present domestic energy production capacity by the end of this century, and do so as our domestic production of petroleum and natural gas declines.

As the Venice meeting of Western nations concluded last autumn, about 90 percent of the free world's new energy production capacity during the next 20 years must come from coal and nuclear fission.

Inasmuch as this subcommittee has jurisdiction for nuclear energy, and not coal, I will not address my remarks to coal, except to observe that we must plan to increase our domestic energy production from coal and similar materials by about two and one-half times—to the equivalent of about 20 million barrels of oil per day by the year 2000.

By that date we must also have about 400 nuclear powerplants on the line, with a capacity of 1,000 to 1,200 MWe each. Today we have 71 plants on the line, with a total capacity of about 53,000 MWe. Of course, you know we also have about 90 plants in the pipeline. These plants can be on line during the 1980's, but this is less than one-half our requirement for the year 2000, and a nuclear industrial infrastructure must accompany these 400 plants, just as for any other industry.

I think it is important to recognize, Madam Chairman, in these days when we are talking about economics, that each nominal 1,000 MWe plant, operating about two-thirds of the time, which is normal, produces 6 billion kilowatt-hours of electricity per year. At

5 cents per kilowatt-hour, the revenue to such a plant is $300 million per year.

Each nuclear plant also replaces a bit more than 10 million barrels of oil per year, if the oil were used to produce electricity. Four hundred nuclear plants in the year 2000—averaging 1,000 to 1,200 megawatts electric—and slightly more efficient than today's plants—will produce the electric energy equivalent of about 13 million barrels of oil per day, about 20 percent of our total energy consumption at that time, and twice our present imports of oil.

One can easily appreciate the vital contribution that nuclear energy will make to our Nation's strength and stability at that time, second only to coal.

Since we know that nuclear fission is the cheapest, safest, cleanest, and most environmentally acceptable significant energy source available, the questions that face us today deal with what we must do to reach our nuclear goals and help protect this country from the catastrophe that certainly awaits us if we do not relieve ourselves of our dependence on imported oil, or if we fall short of the energy production capacity that we must have for a stable economy, jobs for the poor, national defense, and environmental protection.

There are three primary lines of attack in optimizing our nuclear energy production. One is regulatory. Much needs to be done to drain the swamp of confusion, indecision, obstruction, overregulation, and redtape that is keeping our nuclear plants needlessly off the line. However, I will not discuss the needed regulatory changes today, especially since this subcommittee does not have jurisdiction in such matters.

I will mention, only in passing, the second area of attack which must, sooner or later, be faced. This is the need for capital formation for energy facilities in our country. It applies not only to nuclear energy, but to all major new energy installations. The capital cost for our energy requirements during the balance of this century will inevitably run to several trillion dollars. A mechanism must be found to make capital formation of this magnitude a reality.

This subcommittee's jurisdiction over nuclear energy research, development, and demonstration carries with it a great responsibility, and there are several specific projects concerning which I would like to make recommendations at this time.

The first, of course, is the Barnwell Nuclear Fuel Plant. As you will recall, Madam Chairman, this subcommittee and the full Committee on Science and Technology reported legislation last year which directed the Department of Energy to enter into negotiations with the owners of the Barnwell facility to purchase the plant to provide:

First, a spent-fuel storage facility; and

Second, the foundation for a multinational nuclear fuel cycle center demonstration.

There has been ample testimony to the effect that the establishment of such a multinational fuel cycle center demonstration would constitute the most realistic and effective nonproliferation initiative that anyone has suggested.

The concept involves modifying the existing Barnwell plant to give it a "co-processing" capability in which purified plutonium would never be produced. Rather, the plutonium would not be separated from the uranium stream and, thus, would be useless and unworkable for any kind of explosive device. The two product streams from the plant would flow immediately to adjoining facilities: The uranium and plutonium stream to an advanced fuel fabrication facility; and the waste to a glassification facility.

Functionally, the fuel cycle center demonstration would simply lease new fuel elements to both foreign and domestic customers on condition that the spent fuel be returned for reprocessing and that IAEA supervision follow fuel elements leased by utilities outside the United States.

One will recognize the great attraction such a facility would have to small nations which own one or two or three, or even half a dozen nuclear plants; nations which should not be involved in the tremendously complex and expensive business of reprocessing, if only for reasons of economics. A multinational fuel cycle center would constitute an attractive mechanism for them to provide for their nuclear fuel cycle requirements.

It is my understanding the administration has concluded not to purchase the Barnwell facility in fiscal 1982. I think this is unfortunate, but it does not preclude funding continued research and development at Barnwell and detailed studies of the multinational fuel cycle center and negotiations to purchase the facility in the future.

I urge, Madam Chairmen, that this subcommittee authorize such a program, and direct the Secretary to move forward aggressively with it.

The next subject is radioactive waste. I am pleased to learn that new legislation has been submitted this year by Chairman Fuqua and you, Madam Chairman, along with Congressmen Goldwater and Lujan. I understand that this bill is similar to one which Congressman Goldwater and I authored last year and which was, unfortunately, referred to other committees and killed.

I understand also that the new bill provides for only two demonstration sites.

While I still believe that four sites are much better than two and would provide a significantly better understanding for a higher percent of the people of this country of the simplicity and safety of the geologic storage of glassified waste, still I am pleased that the bill has been submitted, and I encourage you to move forward aggressively with it.

It is important to continually reemphasize the basic fact that this country, as well as other countries, possess several technologies and methods by which all radioactive waste material can be simply and cheaply removed from the biosphere forever.

These technologies exist. They are cheap and they are simple and they are in operation in other countries.

The only problems associated with handling nuclear wastes are political problems, Madam Chairman, and this subcommittee can provide a definite service to the country by establishing programs that demonstrate that fact.

There are two other points with respect to radioactive waste.

One has to do with Three Mile Island. We are experiencing totally inexcusable delays in cleaning up the Three Mile Island plant, especially in removing the waste water from the plant. It can be done simply with existing technology.

Here again, the problems are almost entirely political. It is a simple matter to remove the wastes from the water in the TMI plant using ion exchange columns, and then to convert to glass the resins that would be used to completely clean the water, along with the old resins already there.

Unfortunately we are witnessing what appears to be an attempt to find the most expensive and time-consuming method of carrying forth these simple operations, and I urge the subcommittee to support a program to demonstrate the simplicity with which wastes can be removed by funding a program such as I have described.

A similar situation exists with respect to the West Valley high-level waste glassification project. I have reviewed an agreement signed by the State of New York and the U.S. Department of Energy, presumably to implement the intent of the law which was enacted last year for West Valley high-level waste glassification.

In my opinion, there has been an attempt to add every conceivable expense that might be associated in any way with West Valley or the wastes and make it appear that these expenses are attributed to the glassification operation itself. In cost statements supporting the draft environmental impact statement for West Valley, one item alone for removal of the waste to some other site is estimated at $158,570,000. This is simply thrown in, along with other costs and a contingency fee of 25 percent, to make a project that should not cost more than $50 million appear to cost as much as $490 million.

Madam Chairman, I urge the subcommittee to instruct its staff members to thoroughly explore what the realistic cost estimates for this project should be and to authorize funding only at that level.

On a different subject, I would like to suggest that the subcommittee exercise great caution in moving forward with advanced isotope separation technologies. The use of laser energy to make isotopic separation possible is still evolving and all three of the projects now in the development state appear to be most promising indeed.

However, advances in laser technologies may beneficially impact the efficiency of one or more of these systems during coming months, and I strongly suggest that the subcommittee resist—and instruct the Department of Energy to resist—any suggestion that choices between these technologies be made before fiscal 1984.

Madam Chairman, as you will recall, the Subcommittee on Energy Research and Production has consistently supported continuation of research and development associated with the high-temperature gas-cooled reactor.

It is my understanding that the administration has been quite ambivalent on this subject during recent days.

I recommend most sincerely that this program be continued. The high-temperature gas-cooled reactor is unquestionably an unusually attractive device which has proved itself at the Peach Bottom plant near Baltimore, and at the Fort St. Vrain plant near Denver, Colo. The HTGR will not threaten the light-water nuclear plant industry, but it has special advantages in areas where there is a shortage of cooling water, and in cases where high-temperature gases may be needed for hydrogen production or other chemical processes.

Madam Chairman, I know you share my enthusiasm for the breeder program, and that you are as pleased as I am that the administration will recommend moving forward with construction of the Clinch River breeder project.

We are, of course, far behind schedule, and the delays of the last 4 years will cause serious cost overruns. However, we must proceed with construction of the Clinch River breeder plant at the earliest practical date.

Mrs. **Bouquard**. This is something we have looked forward to for about 4 years with hard work and perseverance.

Mr. **McCormack**. Yes. In addition, we must recognize that we are, because of the delays of the last 4 years, also far behind schedule in placing a commercial-size demonstration liquid metal fast breeder on line. I am convinced that we will need to be in a position to commit ourselves to a breeder commercialization program by 1995.

I am aware of the fact that there are faint hearts who are afraid to say that our projected nuclear demand for the year 2000 will require such a commitment, but the only thing that could possibly change that picture in a strong, vigorous, and economically healthy United States would be the discovery of very large amounts of uranium, perhaps doubling our known reserves of reasonably-priced ore.

Therefore, I suggest that in addition to moving forward with the construction of the Clinch River plant, the subcommittee direct the administration to start at once with a specific plan to have a commercial size liquid metal fast breeder demonstration plant on line by no later than 1994.

It may be that this could be a joint venture with the British and/or the Japanese, and/or other nations. In any event, we must remember that the purpose of developing a breeder technology is to insure that we have adequate nuclear fuel when we will need it in the future, and one can easily draw responsible and realistic scenarios which would indicate that the date when the commitment to breeder technology will be required to assure an adequate supply of nuclear fuel may come by 1995.

Finally, Madam Chairman, I must address myself to the budget for the magnetic fusion program for fiscal year 1982. It is my sincere belief that the most important piece of legislation enacted by the last Congress was the Magnetic Fusion Energy Engineering Act of 1980. This law, which commits this country to an Apollo-like program to have a magnetic fusion demonstration plant on line, generating electricity before the end of the century, is all-important to our Nation.

In enacting this legislation, we committed this country to an expenditure of $20 billion over the next 20 years; and specifically to an expenditure level of $525 million in fiscal year 1982.

An analysis of this program, which your staff can provide for you, will demonstrate conclusively that we cannot reach our goal for the year 2000 if we do not fund the program at the level we have already set for fiscal 1982.

The only way this could be done would be by spending much more in the near future to catch up, and we couldn't wait very long even to do that. I am told that the administration will request a budget level of about $455 million for the magnetic fusion progam.

The difference between this level and the level to keep the program on schedule is about $70 million. It is also the difference between moving forward or not with critical projects already underway, such as the fusion materials irradiation test facility; and starting critically needed projects, such as the Center for Fusion Engineering and the fusion engineering device.

Madam Chairman, the United States has, during the last 3 years, taken the lead in magnetic fusion energy development. With the new law, we set forth on one of the most important adventures in all history—developing a technology that will provide absolutely unlimited supplies of cheap, clean energy for all mankind forever.

To abandon this commitment now in order to save $70 million would be an act of extraordinary folly, virtually without parallel. It would constitute the abandonment of one of the truly significant initiatives undertaken by this Government in many years and would be a betrayal of the faith that so many people in this country and around the world have placed in the Congress.

It may be, Madam Chairman, that the question of our national commitment to a fusion engineering and development program and the goals which we have set will constitute the same sort of challenge for this subcommittee that the struggle over the breeder program constituted during the last 4 years. I hope this is not to be the case.

I hope that the administration will come to recognize that scientists and men and women of good will across this country and all over the world recognize the goals of the Magnetic Fusion Energy Engineering Act of 1980 to be one of the most important undertakings of mankind during this period of history.

Whatever the administration attitude may be, however, the Congress of the United States has already indicated its overwhelming support for the fusion program, and I trust that this subcommittee will respond to that support by funding the program at its full level of $525 million.

Madam Chairman, I have only one closing comment. That is that since Congressman Goldwater and you and I started on this campaign for responsible energy programs for our country, we have repeatedly taken the initiative in providing constuctive leadership of the country. In the Solar Heating and Cooling Demonstration Act, the omnibus solar energy R.D. & D. law, in the Solar Photovoltaic Act, the geothermal program, the Energy Extension Act, the Automobile Propulsion Act and the new fusion law. We led the way. All of these programs were either not supported or were opposed by the administration then in office.

This committee has provided the leadership of energy for 8 years. We provided the leadership with the electric car bill where we overrode a Presidential veto, and we provided the leadership for 4 years to maintain the breeder program.

I hope the members of this committee will recognize the fact that the Congress must have an equal voice in policymaking, and that this voice must be exercised at the subcommittee level, expecially in the case of programs such as we have been discussing today.

I hope the committee will have the courage and assert the leadership necessary to insure that responsible energy programs are continued.

Mrs. Bouquard. Thank you very much, Mike. I think everyone in the audience can see why we wanted to wind up the testimony with your perspective and with an overview of the program by this distinguished panel today and as we begin our markup on our budget hearings tomorrow.

Mr. Conway, would you discuss for the record how you feel that electricity, economically compares with oil for our residential heating?

I think this should be established as part of our record in view of statements that have been made in this committee.

Mr. Conway. The price of imported oil continues to rise. A perfect example is in the northeast area, New York power pool area. ConEdison, when I first went to work for the company, was paying $2 a barrel for oil. Today, the cost is $42 a barrel.

At one time, the company was burning, as I recall, 50 million barrels a year. When you go from $2 a barrel to $43 a barrel and multiply by 50 million, you can see the tremendous cost that is passed on to consumers.

Fortunately the New York City area is served by two nuclear plants—one owned by the ConEdison company and the other by the New York Power Authority. Those two plants, as pointed out, being around the size of 1,000 megawatts, can displace 10 million barrels of oil a year each, so 20 million of that does not have to be purchased overseas by that company and the fuel savings are passed on to the consumers.

The last testimony I saw, one nuclear plant in the ConEd system is saving its customers about $400 million a year. When oil was cheap people could use it for heating their homes. As the cost of heating oil has risen, as the cost of residual oil has risen, it is getting to the point where the average person in the Northeast and presumably all through the northern parts of our country are hard put to meet the costs of that heating oil.

When a home is heated by oil, you have to order it ahead of time and pay for the inventory, cash on the barrelhead in most cases and a large sum must be spent by the homeowner up front. That is all paid for prior to the use of the heating oil.

The homeowner, using electric resistant heating, only pays for the cost of the energy after it has been used and does not have to carry that large inventory.

The advancements that have been made by equipment manufacturers, such as GE, Westinghouse and others, in heat pumps has put it to the point where we are competetive today, with the cost of heating oil. As the cost of natural gas is rising also with deregulation, we are finding that with heat pumps, electric heating is economically competitive with alternative forms of heating.

We anticipate, of course, that the cost of petroleum products will continue to rise as the OPEC nations continue to raise their prices throughout the world. There is no question in my mind today in major portions of the country electric resistance heating coupled with the heat pump will be displacing oil and gas as a heating fuel.

Mrs. **Bouquard**. Thank you very much.

Mr. **Kearney**. Could I add a point to that that might be helpful. Within the last 3 or 4 years over 50 percent of all new residences in the United States are going to be heated by electricity. Now, part of this is undoubtedly due to some areas of the country where there are restrictions on new customers for gas, but a larger percentage of it is also due to the sheer economics of it.

Mr. **McCormack**. Madam chairman; May I also comment? I am certain that any comparison will show that heating a house any place in the country with a heat pump is cheaper than heating the same house with oil.

I should like to point out that on average, more than 3 million barrels of oil a day is being burned in this country for space heating in private residences, and, I think, about 1 million barrels a day for heating other buildings. A substantial portion of that heating could be better done with electric heat pumps. It would be cheaper in most cases, including the cost installation.

This is one of three areas in which we can cause a significant reduction in the consumption of imported oil. Heat pumps in residences and other buildings is one. The second is in the production of electricity. We are still using a lot of oil for that purpose along the east coast and in California. We replace this with electricity from nuclear energy or coal. The third is electric cars.

There are two aspects of the energy crisis. The first is our dependence on imported oil.

The second is the need to produce adequate amounts of economical energy from realistic sources—adequate to allow for needed growth and economic stability in the near future.

In three areas: replacing the use of oil for space heating, in burning oil for base load electricity, and in getting electrical cars on our streets, would do more than anything else we could do in the short run to reduce our dependence on oil imports.

[The prepared statement of Mr. McCormack follows:]

# TESTIMONY BY THE HONORABLE MIKE McCORMACK BEFORE THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION, COMMITTEE ON SCIENCE AND TECHNOLOGY

MARCH 10, 1981

Thank you, Madam Chairman. Good morning, ladies and gentlemen.

I am indeed pleased to have this opportunity to return to the Subcommittee, even if it is to this side of the witness table, and to share with you some thoughts and ideas relating to our nation's energy programs and policies -- and to your primary arena of responsibility -- nuclear energy.

In a very real sense, I'm appearing before you in the confidence that this Subcommittee will continue the traditions that we have established in the past -- traditions of strength - courage - dedication to serve the Congress and the country well -- and, as part of such traditions, an insistence on truth, a realistic perspective, and the application of common sense.

I know, Madam Chairman, that you will provide the strength and wisdom and leadership to insure that the Subcommittee will meet these challenges -- and I congratulate you on your chairmanship.

I want you to know that I am -- and will continue to be -- available to be of assistance and service to you and to all the members of the Subcommittee.

My testimony today is set against the same background that has motivated the Science and Technology Committee's energy activities for eight years -- the critical need for this nation to develop economically competitive, environmentally acceptable, practical technologies for producing significant amounts of energy from realistic domestic sources.

The basic facts of the energy crisis will continue to hang a Sword of Damocles over our heads until we eliminate our dependence on imported oil; and we will make little progress in that direction until we come to terms with the fact that even if we are extraordinarily successful with spartan conservation programs, we must approximately double our present domestic energy production capacity by the end of this century, and do so as our domestic production of petroleum and natural gas declines.

As the Venice Meeting of Western Nations concluded last autumn, about 90% of the free world's new energy production capacity during the next twenty years must come from coal and nuclear fission. Inasmuch as this Subcommittee has jurisdiction for nuclear energy, and not coal, I will not address my remarks to coal, except to observe that we must plan to increase our domestic energy production from coal and similar materials by about 2½ times -- to the equivalent of about 19 million barrels of oil per day by the year 2000.

By that date we must also have about 400 nuclear power plants on the line, with a capacity of 1000 to 1200 MWe each. Today we have 71 plants on the line, with a total capacity of about 53,000 MWe. We also have about 90 plants in the pipeline. These plants can be on line during the 1980s, but this is less than one-half our requirements in the year 2000, and there is a nuclear industrial infrastructure that must accompany them.

Each nominal 1000 MWe plant, operating about two-thirds of the time (which is normal) produces six billion kilowatt hours of electricity per year. At five cents per kilowatt hour, the revenue to such a plant is $300 million per year. Each nuclear plant also replaces a bit more than ten million barrels of oil per year, if the oil were used to produce electricity. Four hundred nuclear plants in the year 2000 -- averaging 1000 to 1200 megawatts electric -- and slightly more efficient than today's plants -- will produce the electric energy equivalent of about 13 million barrels of oil per day, about 20% of our total energy consumption at that time. One can easily appreciate the vital contribution that nuclear energy will make to our nation's strength and stability.

Since we know that nuclear fission is the cheapest, safest, cleanest, and most environmentally acceptable significant energy source available, the questions that face us today deal with what we must do to reach our nuclear goals and help protect this country from the catastrophe that certainly awaits us if we do not relieve ourselves of our dependence on imported oil, or if we fall short of the energy production capacity that we must have for a stable economy, jobs for the poor, national defense, and environmental protection.

There are three primary lines of attack in optimizing our nuclear energy production. One is regulatory. Much needs to be done to drain the swamp of confusion, indecision, obstruction, over-regulation, and red tape that is keeping our nuclear plants needlessly off the line. However, I will not discuss the needed regulatory changes today, especially since this Subcommittee does not have jurisdiction in such matters.

I will mention, only in passing, the second area of attack which must, sooner or later, be faced. This is the need for capital formation for energy facilities in our country. It applies not only to nuclear energy, but to all major new energy installations. The capital cost for our energy requirements during the balance of this century will inevitably run into several trillion dollars. A mechanism must be found to make capital formation of this magnitude a reality.

This Subcommittee's jurisdiction over nuclear energy research, development and demonstration carries with it a great responsibility, and there are several specific projects upon which I would like to make recommendations at this time.

The first is the Barnwell Nuclear Fuel Plant. As you will recall, Madam Chairman, this Subcommittee and the full Committee on Science and Technology reported legislation last year which directed the Department of Energy to enter into negotiations with the owners of the Barnwell facility to purchase the plant to provide: first, a spent fuel storage facility; and second, the foundation for a multi-national nuclear fuel cycle center demonstration. There has been ample testimony to the effect that the establishment of such a mutli-national fuel cycle center demonstration would constitute the most realistic and effective non-proliferation initiative that anyone has suggested.

The concept involves modifying of the existing Barnwell plant to give it a "co-processing" capability in which purified plutonium would never be produced. Rather, the plutonium would not be separated from the uranium stream and, thus, would be useless and unworkable for any kind of explosive device. The two product streams from the plant would flow immediately to adjoining facilities: the uranium and plutonium stream to an advanced fuel fabrication facility; and the waste to a glassification facility.

Functionally, the fuel cycle center demonstration would simply lease new fuel elements to both foreign and domestic customers on condition that the spent fuel be returned for reprocessing and that IAEA supervision follow fuel elements leased by utilities outside the United States.

It is my understanding that the Administration has concluded to not fund the purchase of the Barnwell facility during Fiscal 1982. I think this is unfortunate, but it does not preclude funding continuing research and development at Barnwell, detailed studies of a multi-national fuel cycle center, and negotiations for purchase of the facility. I urge, Madam Chairman, that this Subcommittee authorize such a program, and direct the Secretary to move forward aggressively with it.

The next subject is radioactive waste. I am pleased to learn that new legislation has been submitted this year by Chairman Fuqua and you, Madam Chairman, along with Congressmen Goldwater and Lujan. I understand that this bill is similar to one which Congressman Goldwater and I authored last year and which was, unfortunately, referred to other committees and killed. I understand also that the new bill provides for only two demonstration sites. While I still believe four sites are much better than two and would provide a significantly better understanding for a higher percent of the people of this country of the simplicity and safety of the geologic storage of glassified waste, still I am pleased that the bill has been submitted, and I encourage you to move forward aggressively with it. It is important to continually re-emphasize the basic fact that this country, as well as other countries, possess several technologies and methods by which all radioactive waste material can be simply and cheaply removed from the biosphere forever. The only problems associated with handling nuclear wastes are political problems, Madam Chairman, and this Subcommittee can provide a definite service by establishing programs that demonstrate that fact.

Under the heading of radioactive waste management, I would like to call your attention to the fact that there have been endless, meaningless, and expensive delays in removing the waste water from the Three Mile Island plant, delays in moving forward with the program to remove the core from the Three Mile Island reactor, and clean up the plant. Here again, the problems are almost entirely political. It is a simple matter to remove the wastes from the water in the ~~West Valley~~ TMI plant using ion exchange columns, and then to convert to glass the resins that would be used to completely clean the water, along with the old resins already there. Unfortunately, we are witnessing what appears to be an attempt to find the most expensive and time consuming method of carrying forth these simple operations, and I urge the Subcommittee to support a program to demonstrate the simplicity with which wastes can be removed by funding a program such as I have described.

A similar situation exists with respect to the West Valley high-level waste glassification project. I have reviewed an agreement signed by the State of New York and the U.S. Department of Energy, presumably to implement the intent of the law which was enacted last year for West Valley high-level waste glassification. In my opinion, there has been an attempt to add in every conceivable expense that might be associated in any way with West Valley or the wastes and make it appear that these expenses are attributed to the glassification itself. In cost statements supporting the draft environmental impact statement for West Valley, one item alone for removal of the waste to some other site is estimated at $158,570,000. This is simply thrown in, along with other costs and a contingency fee of 25%, to make a project that should not cost more than $50 million appear to cost as much as $490 million. Madam Chairman, I urge the Subcommittee to instruct its staff members to thoroughly explore what the realistic cost estimates for this project should be and to authorize funding only at that level.

On a different subject, I would like to suggest that the Subcommittee exercise great caution in moving forward with advanced isotope separation technologies. The use of laser energy to make isotopic separation possible is still evolving and all three of the projects now in the development state appear to be most promising indeed. However, advances in laser technologies may beneficially impact the efficiency of one or more of these systems during coming months, and I strongly suggest that the Subcommittee resist -- and instruct the Department of Energy to resist -- any suggestion that choices between these technologies be made before Fiscal 1984.

Madam Chairman, as you will recall, the Subcommittee on Energy Research and Production has consistently supported continuation of research and development associated with the High Temperature Gas-Cooled Reactor. It is my understanding that the Administration has been quite ambivalent on this subject during recent days. I recommend most sincerely that this program be continued. The High Temperature Gas-Cooled Reactor is unquestionably an unusually attractive device which has proved itself at the Peach Bottom Plant near Baltimore, and at the Fort St. Vrain Plant near Denver, Colorado. The HTGR will not threaten the light water nuclear plant industry, but it has special advantages in areas where there is a shortage of cooling water, and in cases where high temperature gases may be needed for hydrogen production or other chemical processes.

Madam Chairman, I know you share my enthusiasm for the breeder program, and that you are as pleased as I am that the Administration will recommend moving forward with construction of the Clinch River Breeder project. We are, of course, far behind schedule, and the delays of the last four years will cause serious cost overruns. However, we must proceed with construction of the Clinch River Breeder plant at the earliest practical date.

In addition, we must recognize that we are, because of the delays of the last four years, also far behind schedule in placing a commercial size demonstration Liquid Metal Fast Breeder on the line. I am convinced that we will need to be in a position to commit ourselves to a breeder commercialization program by 1995. I am aware of the fact that there are faint hearts who are afraid to say that our projected nuclear demand for the year 2000 will require such a commitment, but the only thing that could possibly change that picture in a strong, vigorous, and economically healthy United States would be the discovery of very large amounts of uranium, perhaps doubling our known reserves of reasonably priced ore. Therefore, I suggest that in addition to moving forward with the construction of Clinch River, the Subcommittee direct the Administration to start at once with a specific plan to have a commercial size Liquid Metal Fast Breeder demonstration plant on the line by no later than 1994. It may be that this could be a joint venture with the British and/or the Japanese, and/or other nations. In any event, we must remember that the purpose of developing a breeder technology is to insure that we have adequate nuclear fuel when we will need it in the future, and one can easily draw responsible and realistic scenarios which would indicate that the date when the commitment to breeder technology will be required to assure an adequate supply of nuclear fuel may come by 1995.

Finally, Madam Chairman, I must address myself to the budget for the magnetic fusion program for FY 1982. It is my sincere belief that the most important piece of legislation enacted by the last Congress was the Magnetic Fusion Energy Engineering Act of 1980. This law, which commits this country to an Apollo-like program to have a magnetic fusion demonstration plant on the line, generating electricity before the end of the century, is all-important to our nation. In enacting this legislation, we committed this country to an expenditure of $20 billion over the next twenty years; and specifically to an expenditure level of $525 million in FY 1982. An analysis of this program, which your staff can provide for you, will demonstrate conclusively that we cannot reach our goal for the year 2000 if we do not fund the program at the level we have already set for Fiscal 1982. The only way this could be done would be by spending much more in the near future to catch up, and we couldn't wait very long even to do that. I am told that the Administration will request a budget level of about $455 million for the magnetic fusion program. The difference between this level and the level to keep the program on schedule is about $75 million. It is also the difference between moving forward or not with critical projects already underway, such as the Fusion Materials Irradiation Test Facility; and starting critically needed projects, such as the Center for Fusion Engineering and the Fusion Engineering Device.

Madam Chairman, the United States has, during the last three years, taken the lead in magnetic fusion energy development. With the new law, we set forth on one of the most important adventures in all history -- developing a technology that will provide absolutely unlimited supplies of cheap, clean energy for all mankind forever. To abandon this commitment now in order to save $75 million would be an act of extraordinary folly, virtually without parallel. It would constitute the abandonment of one of the truly significant initiatives undertaken by this Government in many years and would be a betrayal of the faith that so many people in this country and around the world have placed in the Congress.

It may be, Madam Chairman, that the question of our national commitment to a fusion engineering and development program and the goals which we have set will constitute the same sort of challenge for this Subcommittee that the struggle over the breeder program constituted during the last four years. I hope this is not to be the case. I hope that the Administration will come to recognize that scientists and men and women of good will across this country and all over the world recognize the goals of the Magnetic Fusion Energy Engineering Act of 1980 to be one of the most important undertakings of mankind during this period of history. Whatever the Administration attitude may be, however, the Congress of the United States has already indicated its overwhelming support for the fusion program, and I trust that this Subcommittee will respond to that support by funding the program at its full level of $525 million.

Madam Chairman, this concludes my testimony. I will be happy to answer questions.

Mrs. **Bouquard**. Thank you.

Mr. Goldwater.

Mr. **Goldwater**. Thank you, Madam Chairman.

Mike, you cautioned this committee about advanced isotope separation. We exercise great caution in moving forward with these technologies. As I understand, we are reaching a phase where we are starting to scale up and to demonstrate these advanced technologies.

Do you see, one, that the technology is useful, that it has potential and can make a significant contribution, and, second, how should we evaluate this program as the costs obviously will accelerate as we get into greater magnitude of scale?

Mr. **McCormack**. Barry, I can't give you a definitive answer that I would want to stake my career on at this moment. However, I will make one suggestion.

I don't believe it is clear at this moment that any one of these technologies is totally superior to the other. I don't think we have enough experience in any one to stake our future on it alone.

I recognize we are going to be scaling up in the near future. I would like to suggest an economic analysis be made to determine whether it is practical to build a small pilot plant for each of the three technologies; one in each of our three existing diffusion plants at Portsmouth, at Paducah, and Oak Ridge.

I believe it would be shown that such pilot plants would pay for themselves while we are learning enough about them to make a decision between them for future construction, if we do indeed find that we want to make such a decision. I must emphasize that there appear to be recent dramatic improvements in laser technology that may significantly impact on any decision concerning the AIST program.

I think it would be unwise to choose a specific technology now.

Mr. **Goldwater**. I have one other concern that I think we all have which is in regard to the breeder program. It seems that we are committed or this administration is committed to finishing the Clinch River breeder reactor demonstration facility. But the need that you raise is for a commercial demonstration, a commercial-sized plant?

Mr. **McCormack**. I wanted to emphasize it is not a commercial demonstration, but a commercial-sized plant.

Mr. **Goldwater**. A thousand megawatts?

Mr. **McCormack**. A thousand megawatt, nominal size plant, yes.

Mr. **Goldwater**. Are you telling us we should be proceeding at least in that direction?

Mr. **McCormack**. Yes, I am.

Mr. **Goldwater**. Hastily developing the program?

Mr. **McCormack**. Well, with deliberate haste. Let me suggest that if we are to clear our minds about what we are doing, we will recognize there is no need to license such a plant. It will be a Federal facility. By not licensing such a plant, but building it the same way we built the fast flux facility, we could save at least 2 years, without any sacrifice in safety.

Given that situation, we could easily consider starting construction of such a plant in 1986 or 1987.

Such a schedule might also provide the British with the time for their formal inquiry, a procedure through which they will go before making a commitment to their demonstration breeder. I understand they may do so within the next 2 years. So we might join them and we might also join the Japanese or any combination of nations in the 1,000 MWe LMFBR.

We should be in a position to be able to commercialize, to allow private industry to build breeders starting in 1995.

It may be, Barry, we won't need them. A lot of things can happen between now and then that would change our needs, but it is prudent, I think, to remember that the purpose of the breeder program is to assure us of adequate fuel supplies.

If you will remember the numbers we went through, if one assumes 1.8 million tons of known and assured uranium reserves—as $U_3O_8$—that were assumed last year, and assume a 50-year lifetime for 330 plants of 1,000 MWe size, all of the 1.8 million tons is used, assuming no reprocessing.

We can easily see ourselves in a situation where we might order our 330th plant by the mid-1990's. If a utility goes before a public service commission and says it wants to build a plant, but does not have any fuel, or know where it will come from, it would have great difficulty, I think, in obtaining a license.

If, however we have a national program to provide nuclear fuel based on the knowledge that the breeder program is there, the situation is totally changed.

Mr. **Goldwater**. One of the questions I get asked is "Why should the Federal Government be building a breeder reactor facility?"

I think there is obvious justification for building this demonstration at Clinch River, but then when we go to the larger scale commercial facility, should we not, or would we not learn enough from the Clinch River program to, in essence, turn it over to private fundings?

How can we justify the Federal involvement in building such a facility and if we do, should we not really license this facility so we can get that learning experience and be in a better position to turn it over to private industry and private funding if in fact the technology does prove itself?

Mr. **McCormack**. My feeling is that we should continue with the basic philosophy that has been followed throughout our consideration of energy research, development, and demonstrations programs: any technology that appears to have promise as a realistic energy source should be supported as much as is practical to the point where it can be commercialized, whether it is a photovoltaic cell, a coal gasification process or something else.

As far as the LMFBR is concerned, my feeling is that we can go directly to commercialization from the CRBR plant.

Industry would say that it cannot learn enough from this facility by itself to commercialize. I think we need one more facility.

Mr. **Goldwater**. Do we lose something by not licensing?

Mr. **McCormack**. I think not. My feeling is that we didn't lose a single thing by not licensing FFTF. The DOE did all of the things it would have needed to do if it were going to license, it met all standards that would have been met in constructing and preparing for operation of the plant as if it were going to be licensed. However, the DOE was not required to license the FFTF because it is a Federal facility. I frankly think it is a bad policy to talk of licensing Federal facilities, it is a bad principle, and, in all too many instances, just one more method of delay.

Mr. GOLDWATER. Obviously, if you use the delay, then it makes no contribution.

Mr. MCCORMACK. Well, I might point out to you—excuse me.

Mr. GOLDWATER. If it is not used as a delay, if we expedite the licensing process, is there not something to be learned from that?

Mr. MCCORMACK. I wouldn't argue there is not, but I think the utilities have learned what they need to know about licensing from going through the procedure with conventional plants. The breeder is not much different from a light-water plant. This is not a matter of life and death, it is not the most important factor, but I think we should consider the benefit of saving a couple of years against the time lost in going through the ritual of licensing.

One of the techniques that President Carter used in delaying Clinch River was refusing to do anything about licensing.

Mr. GOLDWATER. But I am assuming that we have a breath of fresh air and a different attitude about licensing and proper role of licensing and I would foresee an expedited kind of cooperative approach by the regulatory agencies.

Mr. MCCORMACK. Well, it is not a question we have to face today. I would not make it a matter of life or death or hang anything on it. But it is a way, I think, to save some time in the future.

Mr. CONWAY. I would associate myself with the comments of Mike McCormack on that point.

I would like to add that the Shippingport reactor, which was the early demonstration for the light-water reactors and, has never been licensed. That is where we in the industry learned all of our early lessons. That project went ahead and followed all safety precautions and has continued to work up to the present and has never gone through a licensing procedure, because it has been a Federal project. The nuclear industry learned from it and the knowledge was carried over to light-water reactors that we are building and licensing today.

Mrs. BOUQUARD. Thank you.

Mr. MCCORMACK. May I show you something, Madam Chairman?

Mrs. BOUQUARD. Go ahead. Yes.

Mr. MCCORMACK. I would like to show you a sample of glass. This sample contains all of the chemicals that appear in the West Valley tank of high level waste. This glass is synthetic West Valley waste.

The glass contains all of the trace elements that appear as fission products in the West Valley tank. This is a superior glass to anything we have seen so far, as measured by leach resistance. It has been made to demonstrate that we can today glassify the West Valley waste very simply, perhaps doing nothing but denitrating the liquid waste before pumping the entire contents of the waste tank directly into the glassification furnace. You may be interested to know that construction of the first demonstration furnace for such an operation is now underway.

You may also remember that several years ago this sub-committee studied the leachability of glass; that is, resistance of glass to leaching in water. Of course, glassified wastes will not be exposed to water, but put in geological formations where water will not get at it.

However, an interesting bit of data has come to light. There are some glass objects that were taken from the bottom of Agean Sea where they had been submerged for 2,000 years. It turned out that the glass leached at the rate of about a millimeter per milenia; that is, one millimeter per thousand years. That was ordinary lime glass, the cheapest glass you can get.

It is used for instance to make such things as pickle jars. This sample has been made using a cold lime glass barrier around synthetic radioactive glass to show how the radioactive glass can be sealed inside the lime glass container.

I will leave these samples with you. You can see the ring of clear glass which is, in this sample, just pickle jar around the synthetic radioactive glass.

One glassification process, proposed for West Valley, would be to put a centimeter-thick layer of ordinary lime glass around the outside of the radioactive glass so that it will seal it in on all sides within a glass container that will be leach resistant for 10,000 years.

All of the glass will, of course, be sealed in a steel container.

Mr. **Goldwater**. This will be inside a steel container?

Mr. **McCormack**. Yes, but even if you were to breech the steel container, you would still have a 10,000-year barrier against leaching in seawater before the radioactive material would be reached. The radio activity would have been essentially decayed away by then.

I bring these to the attention of the subcommittee and leave you these samples, because they demonstrate a technology which is substantially superior to any technology previously considered for solidifying waste.

Mrs. **Bouquard**. I certainly appreciate your mentioning that. I think we should carry our messages that technology is here and it is purely political that we have not moved ahead to assure the public that we can indeed take care of our waste-disposal problems. It certainly is a responsibility we hope we can address this year in our legislation.

Mr. Kearney, before we get off of Clinch River, what would be required of the Federal Government in order to maximize private financing of a large follow-on demonstration plant?

Mr. **Kearney**. I think several things.

One is, I think that if the administration and the Congress would come out with very positive statements as to the role they see for nuclear power in the energy future, I think it would help both the utility industry and the public at large to understand the need for the breeder program.

Second, I think whether we go or not go into a licensing process, I think bringing certainty to the process will also be important in getting an air of confidence within the industry.

The third thing I think is to have a very definite program that is laid out, not on piecemeal, as we have been inclined to do sometimes in the past, again, this would instill confidence and certainty on the part of the industry.

There is, of course, another subject which is beyond the province of this committee, but certainly not beyond the province of the administration and the Congress and that is the overall economic health of the utility industry. There are certain things that can be done to help that along and to the extent that that can be done, I think this also is a step in the right direction of getting the maximum permissible support from the electric utility industry.

Mrs. **Bouquard**. How should the various determinations on the full size demonstration reactor be made?

Mr. **McCormack**. I would hope that we could set up a committee of nuclear scientists and industrialists who would seek the counsel of their colleagues in other countries as well as in the United States and try to determine exactly what we want to do.

There is a basic discussion, of course, Madam Chairman, as to whether we should go with the pool type or loop type LMFBR. I think that is the only basic question we are facing. One could talk about what efficiency we want, but it is an engineering decision, I think, and one would probably choose the side of caution with such questions as that.

I think that there should be such consideration, and I think it should be quick. I believe there could be sound decisions within 6 months and that at that time the United States could make commitments.

It is not a matter that would, I believe, critically harm future decisions no matter how we choose. It is like choosing between a Ford and a Chevrolet. Both of them have good basic designs, and the question is often a matter of preference.

I think we should establish such a study, involve everyone who has significant input to make, but that the arena for the discussion should be limited primarily to the question: "What should the next LMFBR be like?"

We should not be asking: "Should we have one or another type of breeder". The question is "What type of LMFBR?"

Mrs. **Bouquard**. Thank you

Mr. Conway, briefly, would you touch on the institutional obstacles to relying on foreign technology for our breeder program?

Mr. **Conway**. As I think back on the history and evolution of nuclear power, I recall after Sputnik, Congress decided that we needed to cooperate much more closely with our Allies and a bill was passed, which, for the first time, permitted the United States to turn over classified information to the British on our nuclear submarine program. This we did to permit the British to develop their own nuclear submarine.

They were given all of our plans and development. After a year or two, they came back to us and said: Yes, we have it, but don't have the know-how. Would you let us work with you and you build the first one for us?

My recollection is, the first one or two nuclear submarines built were done by the U.S. manufacturers that had know-how. The British came over and had on-the-job training, even though they had been given our drawings.

Thereafter, they took it over. I would suggest that as a perfect example of what will happen if we have to depend on foreign technology. After they have developed and moved ahead of us if we ourselves take their plans and design, I doubt we can do it. We are going to have to get on-the-job training and that will put us far behind them.

Mrs. **Bouquard**. Please comment on the licensing of foreign technology?

Mr. **Conway**. That is another point. Obviously, foreign countries will develop the plants and have been, as they consider them, to be safe.

They have plants, for example, in Canada, the Can-Du plants. I don't know if you could license that plant in the United States. They are operating safely and right across our border, but with the long evolution of rules and regulations out of AEC and now the NRC, I dare say it would be difficult to bring that Canadian reactor here and license it here.

I think it would be the same with the French and others. That is an extremely difficult point for us. If the U.S. Government is going to continue its licensing programs, and which I think they will, new plants and new concepts, as they evolve, must be in step with our own Government regulations and standards so that we can be assured that they will be licensable.

That was one of the reasons I like the idea, as Congressman McCormack pointed out, the need for the Federal Government to move along and demonstrate a plant, as they did with Shippingport, that is satisfactory to the Federal Government. If the Government feels it is safe, then the industry, I think, would feel justified in building others after it has been shown to be commercially adaptable.

But for industry on its own to try to get out there and develop one of these advance concepts while not being quite sure at the tail end whether the United States, NRC, or whatever agency is responsible will license it, is an awful risk for companies to take with investments.

Mrs. **Bouquard**. Thank you.

Mr. Goldwater.

Mr. **Goldwater**. With the administration's reduction in loan guarantees and outright grants for demonstration programs, it seems to me that utilities are going to have to find another means by which they can finance some of these projects.

Now, I never quite understood why these projects cannot be passed on in the rate structure. I am wondering if you can address yourself to the situation that exists:

As long as the Federal Government is there to provide some source of funding or guarantees, then that should facilitate the ability of a utility to proceed with a variety of energy-producing plants. But considering the administration's reduction in this area, where will you get the money to build a plant?

I am thinking specifically of the problem for the geothermal plant in Heber, Calif. The Government removes its support of the project saying it still wants to proceed. Evidently they can't proceed because the cost cannot be passed on to the rate payer until the plant is actually built.

Is there not a need for change in attitude and thinking by utilities and their regulators?

Mr. **Kearney**. That is a many faceted question, Mr. Goldwater. I take it from what you are saying that you are mainly interested not in commercial facilities, but demonstration and research and development facilities?

Mr. **Goldwater**. Where do they get the money to build a commercial facility? Can that be passed on in the rate base?

Mr. **Kearney**. We are having difficulty in building the necessary facilities today because of the high rate of inflation and the fact that we are not getting rate increases on a timely and adequate basis, so there are many problems. As you know, the electric utility industry is the most capital-intensive industry in the United States, so that increasing the cost of money and things of that nature impact more severely on our industry than any other industry.

We are finding difficulties in building new facilities as the incremental cost of building the next facility is greater than the imbedded cost of the plant. We are having trouble with that.

Mr. **Goldwater**. Can you accumulate those dollars through the rate structure as you construct?

Mr. **Kearney**. The problem is that, as you expand the time in which the facility is under construction, and as Mr. Conway pointed out, it may now be from concept to operation as much as 15 years, the moneys that the utility put into that plant, which continued to expand throughout that period, are not eligible for earnings. Only the interest on the money that they spend for construction is eligible.

So that they are finding difficulties in going to the capital market to obtain additional moneys either by selling new common stock—where in most instances, the selling price of utility stocks are below book value, or in trying to sell debt instruments, because of the fact that the utility's earnings are not sufficient to cover the bond interest as required in the mortgage indenture. There are difficulties.

Mr. **Goldwater**. There is a problem in getting rates adjusted from time to time, but most utilities, if they are going to build a 1,000-megawatt coal plant, are they able to accumulate capital dollars through the rate structure to build that facility in advance?

Mr. **Kearney**. No. No, definitely not. The two sources of money for building plants are either internally generated cash which either comes from retained earnings or depreciation, or external, by selling of stock or floating bonds or bank loans.

Now, the investment community is not as anxious to support the expenditures of money as they have been in the past, given the fact that utilities are not getting rate increases to provide adequate earnings and to provide moneys internally to produce these facilities.

It is a problem with existing facilities.

Mr. Goldwater, I don't know of any utility who really wants to go out and build new facilities, but because of their franchise responsibility, they have to do it. That is putting them in a bind. They are in a bind between the Nation which needs more electricity and the ratepaying commissions who are finding difficulty in passing increased rates on to the consumer.

I am afraid I can't give you a magic answer to that. We are certainly working on it.

When you take that situation and then you come and look at the demonstration projects, which are things that are needed down the road, but very important, that becomes more difficult for them to do, and it is because of that that we feel that there is a role for the Federal Government in getting high technology, longer payout projects in the works so that they will be available so the utility industry can use them for the benefit of the consumer after they have been developed.

There are three points that make it difficult for the utility industry in this area:

No. 1, which we have spoken about, is the financial situation of the industry.

No. 2, which I just alluded to, is the uncertainty of the licensing process.

It is difficult for industry to go in and start to develop something and then find out the rules have been changed as we go down the road.

The third thing is the intrinsic cost of high technology with long payout.

It is those three factors, maybe the first two are something that are susceptible to change within our economy if we can get it moving, but the third one, I think, is inevitable and as a matter of principle I think it has to have sufficient help from the Government to start moving.

Mr. **Goldwater**. Well, is it inevitable? Have we become so locked in doing business this way for so long that there cannot be a rethinking, a change?

In this administration, it is not predictable how successful they will be in deemphasizing the role of the Federal Government and placing this responsibility back with the States to manage and to take care of those great variety of problems that the Federal Government now is assuming.

Do you think that there is a responsibility of the States to rethink their role in the funding of these projects? Somehow this attitude that the rate should not carry the burden could be changed; is that unreasonable?

Mr. **Kearney**. Mr. Goldwater, I don't think any new idea is of itself unreasonable. I am somewhat like you, optimistic. I hope in the new climate that we have we somehow will be able to come up with a plan whereby we will be able to do the things we can do and do it in the most cost-efficient manner.

Mr. Conway pointed out, for example, that in building a new nuclear powerplant about half a billion dollars is probably due to the uncertainty in the proliferation of the licensing process, not one of those dollars goes into bricks and mortar. It goes into paper. We ought to be able to turn that around.

I think this is an example of the thing that hopefully we will be able to turn around.

Mr. **Goldwater**. It seems to me it would become quite obvious to State governments that the Federal Government is moving back aways. They have the responsibility of making sure there is sufficient energy for their people that live in that State. I don't think they can sit idly by and just let chaos reign.

Obviously they can't turn their backs away. It would seem the utility companies ought to be in the forefront of educating the States that they are going to have to assume this new role and be responsible and to work with the utilities in finding mechanisms to provide these capital dollars.

Mr. **Kearney**. I don't think there is a utility, Mr. Goldwater, that is not pointing that out to its public utility commission, which are the ones that have jurisdiction over the rates that are charged. But let me point out one thing to you that makes it difficult for the public utility commissions and also for the ratepayers. The Congress in its wisdom will pass a law that will require an electric utility, say, to do something, add new equipment, things of that nature, but in passing that law they don't come up with a solution as to how it is going to be paid. It puts it to another level of government, the State level, and here we are, the utility, caught in between.

We must meet certain air and water environmental regulations, for example, and to do that is an increase in capital cost of the plant. Then it is up to the public utility commission to allow that. We are sort of caught in between. So it has to be, you know, it has to be worked on both levels of Government.

May I finish one more thing?

Mr. **Goldwater**. Yes.

Mr. **Kearney**. When it comes right down to it, if a plant cost $x$ number of dollars, somewhere somebody is going to have to pay for that $x$ number of dollars and it always gets back to whether you call them the consumer or the taxpayer, that is, you know, evidently the only source of money.

The thing we have to do is to try to change that $x$ source of dollars so it is less than $x$, considerably less than $x$.

We also have to remember that the cost of energy is not going to decrease in the future, because of the many things that we know, but we feel that the cost of electricity has, in the long run, an opportunity to rise slower than the cost of other alternatives.

Mr. **Goldwater**. I think what you said is very true and it is the reality of what we have been living with. I guess what I am suggesting is, maybe our experience has proved that perhaps the way we have been going in the past several decades has not been entirely successful and that there needs to be some change in approach to how we have been doing things. I think that is what we are hearing from this administration.

Again, I raise the question as to how successful they will be, the approach of this administration isn't so dramatically different from what we have become accustomed to in the past 50 years and I personally hope that they are successful. I think we have seen too much federalism, too much Federal involvement providing for the needs of the citizens of the State of California primarily and basically it should be the responsibility of the State government, with their own regulatory bodies.

I think what this administration is trying to do is to take some of those hurdles and roadblocks off of the States and at the same time back away from some of the traditional sources of funds or guarantees. Therefore, if this is the theme, and the goal, and the attitude, everybody will stroke together. The utilities generally should be in the forefront of getting their States and their regulators doing their duty and solving how we acquire capital for these capital-intense projects.

I would hate to see you left at the starting gate and be in worse shape than you are today.

Mr. KEARNEY. Mr. Goldwater, let me assure you the question of financing is the No. 1 priority of the Edison Electric Institute and that there are committees of the institute that are looking at this question and, you know, questioning ourselves, "Just because we did it a certain way in the past, aren't there new innovative ways of doing things?"

So it is very much in our minds. As I said before, there isn't an electric utility company that is not working with its public utility commission trying to explain to them the difficulties and the need for continuing an expansion of electric power.

I might also add that in every instance the No. 1 priority to be looked at is conservation, but even if you take that into consideration, there is need for expansion and that is the problem we have to deal with.

Mrs. BOUQUARD. Thank you, Mr. Kearney.

Last Friday, I had the privilege of touring TVA's training center in Chattanooga where they have a very advance program, and I think really as far as I know it is the only one in the world where they have a control room simulator for each of their reactors, is that correct?

Mr. CONWAY. No. There are others. ConEdison was the first to own its own simulator at Indian Point.

Also Commonwealth Edison has one jointly with Westinghouse at their location. There are other utilities that have simulators, but the TVA one which I have not visited, is an excellent one I understand.

Mrs. BOUQUARD. But it is the only one that has a group of simulators in one place of more than one type?

Mr. CONWAY. I believe you are correct on that.

Mrs. BOUQUARD. They have one for each of the manufacturers, which is the point I was trying to make.

Mr. CONWAY. Yes.

Mrs. BOUQUARD. Each manufacturer has its own reactor design which adds to the plant costs and increases the involvement of NRC. While I was at TVA, I brought up the subject of standardization of nuclear plant design. They were very much opposed to this saying this would stifle innovation by the industry.

What are your comments on this? I would like to hear from all of you.

Mr. KEARNEY. I think in principle standardization is good. We have continued to standardize in the elecric utility industry, transformers are standardized, switch gear, and things of that nature.

When you start to get into a very complex piece of plant like the nuclear powerplant or even a coal-fired plant, I think there sometimes occurs that you have to be precise and specific in the type of plant you have there.

There is also different designs that have been made by different manufacturers and, of course, the architect engineers. I do believe in speaking only from the electric utility point of view, that because of the increased cost of nuclear powerplants, that there is great interest in trying to standardize as much as possible.

One of the things is, standardization means different things to different people and we have to sort it out. For example, someone may think a standard plant means that a boiler feed pump is the same, it is just a certain manufacturer that has certain dimensions.

Another way to look at standardization is to say that the standard pump must meet certain specifics and it does not have to be just from a certain manufacturer.

Quite obviously, if the former were the case, we would start to run into antitrust and anticompetitive things, which none of us want. But there is, I think, a greater interest on the part of the electric utility industry in standardization.

I think, as we hopefully get over the hiatus that we have now in new plants, that we will see more of standardization, but on the other hand we have a lot of plants that are in the pipeline right now and I don't think we should do anything to detract from getting those on line.

So, in summary, I would say, there is interest in standardization, it is a complex subject, because plants are complex, but I think we can do a lot in this, but we still want to keep the competitive situation of having more than one manufacturer, as they have in some foreign countries.

Mrs. BOUQUARD. Mike.

Mr. McCORMACK. Madam Chairman, I very much agree with what Mr. Kearney said. I think standardization is an excellent idea. I think it would be quite beneficial if each major vendor were to submit standardized designs as much as practicable, perhaps two or three designs for each vendor, and that these then would be available on the market. We could then license those few models.

I think we must remember, as Mr. Kearney said, there are some problems that must be considered within that. A plant that is acceptable in one place may not be in another for reasons of seismic stability or soil conditions or just simply the character of the location, whether it is by a river, a lake or in a desert. We must take such factors into consideration.

I think it is possible, though, to license basic designs from each vendor quite the same way as we license airplanes, such as DC-10's and DC-9's and 10-11's and 747's, and so on. Then each vendor would have a sort of a stable of plants to offer for sale.

It is important to remember even a licensed commercial airliner may offer a lot of little options. A typical airplane, may be made all coach or part first class, or may have the galley in the middle or up front, et cetera. It may be a stretch or a standard design. These are the type of differences that must be allowed in standardized design of nuclear plants, and the small modification should not cause delays in licensing.

I think that one of the reasons we have not done this is because the NRC has been bogged down in its own morass of confusion and conflict. I believe that a newly constituted NRC (or agency to replace it) could or should do this.

It wouldn't be altogether easy but it can be a major step forward.

Mrs. **Bouquard**. John.

Mr. **Conway**. I would have nothing else to add to the two previous witnesses' statements.

Mrs. **Bouquard**. In other words, it is a good idea but it probably won't work so well.

Mr. **McCormack**. Please don't misunderstand my comments. It is a significant step to get NRC out of the business of reviewing every nut and bolt and design of every single detail of every plant. There are major components of every powerplant that can be standardized for one given vendor and once they are, they can be included in a standard design. Once approved, such components would not be constantly re-reviewed by NRC. This can save a lot of time, and that is important.

Mrs. **Bouquard**. It seems to me this goes to point up part of this issue, most of the specifics by NRC were after the fact, after much of the work had been done, they had to go back and do it over and over.

Mr. **McCormack**. That is all important.

Mrs. **Bouquard**. That is standardization.

Mr. **McCormack**. We simply have to establish that NRC cannot go back and constantly change the detailed design requirement of a plant after it is under construction. The Washington public power supply is building five nuclear plants at once, and NRC has imposed thousands and thousands of design changes on WPPSS, causing delays and huge cost increases that the rate payers must pay. In one instance, I understand that the NRC redesigned the same object five times while the plant was still under construction. This is a colossal waste of money. NRC is splitting small hairs. It is totally unnecessary. This is one of the biggest arguments for standardization; to keep NRC from making changes after the fact.

That is not to say that NRC shouldn't be allowed to do this at all, but such changes should be allowed only if there is a real demonstrated emergency or hazard involved in leaving a design as it is.

Mrs. **Bouquard**. Thank you.

John.

Mr. **Conway**. I would say it is known out in the industry as the "rip and tear approach of the Government." There are really questions, as Mike says, they go in on minor matters and cause a change and then are going in and ripping out something and rebulding it.

It is a question of whether this is really adding to safety, but that it may have an adverse effect on safety. A number of people in industry have raised that point with NRC.

Mrs. **Bouquard**. I was very impressed with the simulator training program and it seems to me all of the operators should have this type of training. I was appalled that the operators at Three Mile Island had no simulator training.

Moving on, as you discussed, Mr. Kearney, the need for AFR storage, could this be financed by the utilities?

Mr. **Kearney**. Well, it is going to be financed by the utilities because they are going to be paying for it. But I am sure that is not what you are asking me.

Mrs. **Bouquard**. Well, what I am really getting at is, a facility such as Barnwell, could it be financed by the utilities or would this indeed have to be done by the Government?

Mr. **Kearney**. Given the history of the actions of the Government in the building of plants, including reprocessing plants, I think at this point in time that it would be a risk of such uncertain magnitude for private industry to try to purchase and complete the building of, and to operate such a facility that it would be unacceptable at this time to the utility industry. I don't see how we could be expected to buy that and not know what, if it is going to be licensed, if the ownership would be acceptable to the State and all of these uncertainties make it a business risk that I don't think the utility industry or industry in general could stand at this time.

Mrs. **Bouquard**. Thank you.

Mr. Goldwater.

Mr. **Goldwater**. No questions.

Mrs. **Bouquard**. We thank you gentlemen for your valuable testimony. We do not often have such knowledgeable witnesses and since some members of the subcommittee could not be here today, we would like to know if we could ask additional written questions of you for the record and would you be willing to respond in writing for the benefit of those members of the subcommittee?

Mr. **Kearney**. We certainly would.

Mrs. **Bouquard**. As you know, we usually have about two or three committee meetings going on at this time of year at the same time. We do a pretty good job up here, but we have not found out a way of being at three places at one time. We have not been able to do that.

Thank you very much and the subcommittee stands adjourned.

[Whereupon at 10:55 a.m. the hearing was adjourned.]

[Additional statements submitted for the record follows:]

JOHN J. KEARNEY, Senior Vice President

**EDISON ELECTRIC**
**INSTITUTE** The association of electric companies

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March 25, 1981

The Honorable Marilyn Lloyd Bouquard
Chairman
Subcommittee on Energy Research and
 Production
Science and Technology Committee
U.S. House of Representatives
B 374 Rayburn House Office Building
Washington, D. C. 20515

Dear Madam Chairman:

On March 10, 1981 I appeared before your Subcommittee and presented testimony on the Department of Energy's Fiscal Year 1982 Budget Request on behalf of the Edison Electric Institute and the American Nuclear Energy Council. In my testimony I indicated industry support for the away-from-reactor (AFR) spent fuel storage program that had been proposed by former President Carter's Administration. The AFR program is not included in the DOE Fiscal Year 1982 Budget Request. As you know, this was not known at the time I testified.

During the hearing, Congressman Ottinger asked that I document the amount of spent fuel requiring storage beyond at-reactor storage capacity and the comparative costs of additional at-reactor and away-from-reactor storage. A table with this information is enclosed. Please note that despite the new Administration's plan to cancel the AFR program, there is a need for the storage of 120 MTU of spent fuel in 1986. This number grows to 6,480 MTU by 1995. These figures are based on maximum re-racking of pools at-reactor and no transshipment between reactors. If transshipments are included, the need becomes 100 MTU in 1987 and 4,440 by 1995. As far as costs are concerned, only an individual utility can assess its own options and costs for spent fuel storage. However, it is clear from this information that whenever possible, spent fuel storage requirements will be met by re-racking existing reactor basins and/or transfer of fuel to available space in other reactor basins within a utility system. However, as the excess storage requirement numbers discussed above indicate, not all the spent fuel storage requirements can be met in this manner. A certain amount of additional spent fuel storage capacity is required and cost figures show that a Federally-owned AFR facility is the least expensive way to provide that capacity. As I pointed out in my testimony, this capacity is required even if the ban on reprocessing nuclear fuel was lifted today.

I hope you and your Subcommittee find this information helpful. We stand ready to assist the Congress in its deliberations on President Reagan's Fiscal Year 1982 DOE Budget Request.

Sincerely,

John J. Kearney

John J. Kearney

JJK:ski

Enclosure

cc: The Honorable Richard L. Ottinger

## SPENT FUEL STORAGE

### Requirements in Excess of At-Reactor Capacity*

| YEAR | CUMULATIVE MTU<br>Re-racking | <br>Re-racking and Transshipment |
|---|---|---|
| 1981 | 0 | 0 |
| 1982 | 0 | 0 |
| 1983 | 0 | 0 |
| 1984 | 0 | 0 |
| 1985 | 0 | 0 |
| 1986 | 120 | 0 |
| 1987 | 390 | 100 |
| 1988 | 620 | 290 |
| 1989 | 1,240 | 600 |
| 1990 | 1,800 | 860 |
| 1995 | 6,480 | 4,440 |
| 2000 | 16,010 | 13,640 |

### Comparative Costs

| | |
|---|---|
| Transshipment (within utility system) | - small compared to others (Ref. A) |
| Re-racking (at-reactor) | - $8,000/MTU** (Ref.A) |
| Away-From-Reactor | - $121,000/MTU (Ref.B) |
| At-Reactor (new water basin) | - $320,000/MTU (Ref.A) |

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* Source: Data compiled by DOE from utility company input during the summer of 1980.

** Highly variable due to site characteristics and storage requirements.

Reference A: Spent LWR Fuel Storage Cost Re-racking, AR Basins, and AFR Basins, DOE/SR-SF-2002, U.S. DOE, December 1979

Reference B: Report on Fee for Spent Nuclear Fuel Storage and Disposal Services, DOE/SR-0006, October 1980

# A STATEMENT BY

ROBERT B. RICHARDS

FOR SUBMISSION TO THE

ENERGY RESEARCH AND PRODUCTION SUBCOMMITTEE

OF THE

U. S. HOUSE OF REPRESENTATIVES

MARCH 10, 1981

My name is Robert B. Richards and I am the General Manager of the Advanced Reactor Systems Department of the General Electric Company. The charter of this Department includes, among other activities, responsibility for our Company's activities in the field of the Liquid Metal Fast Breeder Reactor (LMFBR). We are pleased to have this opportunity to submit our views on the role this technology may have to play in this nation's future energy policy to this subcommittee.

We have appeared before this and other Congressional groups for many years in support of nuclear power. We have come as part of a nuclear community whose contribution to the country's energy future has been the subject of widespread debate. We believe it is time to reassess this debate along with oil, gas, and electricity which serve 95% of the nation's energy needs. These three energy forms will probably continue to serve most of our needs, but national security demands a reapportionment of their shares. The objective of this reassessment is to reduce the consumption of imported oil.

Today the oil we consume in sit-still burners is equal to one-third of the oil we use in the U. S. Since we have alternatives for these applications such as gas, and electricity derived from coal and uranium, we believe the time has come to increase our use of these substitutes. Both coal and nuclear energy are options we must not lose.

Our first item of priority in the nuclear community must be the restoration of health and viability to light water reactors. The nation must also develop the capability to deploy breeder reactors for that time when low cost uranium resources are depleted.

It is as true today as at the beginning of the commercial nuclear age that, in order to derive the greatest benefit from uranium, breeder reactor technology must be developed. The breeder reactor will make it possible to extract more than 60 times the energy from uranium than can be done with light water reactors.

Oil is now and will continue to be too valuable to be used in applications other than petrochemicals and transportation. Natural gas, if it were available in sufficient quantity at a competitive price, would be an excellent substitute fuel in fixed installations.

But, essentially all projections of natural gas production from conventional sources in the lower 48 states show a continuing decline. Unconventional sources of gas may augment this to a significant extent, but much more exploration and drilling will be required before success is assured.

Coal, nuclear and hydro are all basic energy sources available for the generation of electricity. Much of the nation's hydro power resource has already been exploited, but large indigenous coal and uranium resources exist. By expanding coal and nuclear generating capacity, the United States can provide electricity in quantities sufficient to meet almost any conceivable demand. However, because planning, licensing, fabrication and construction of central power stations is a time consuming process, the effort to expand electricity production must be initiated well in advance of the actual need. Only through anticipation and long-term planning will tomorrow's electricity demands be satisfied.

Except for transportation, which requires portable reservoirs of energy, it is technically feasible for consumers to meet much of their energy needs with electricity. This is particularly true in the residential and commercial sectors, where fuel use is largely heating.

New electricity generating capacity can be planned, and installed to produce a predictable energy supply for a definite period of time. The American electrical industry has the capacity to provide the reliable electricity this nation has grown accustomed to expect. The industry's suppliers are capable of producing about 30 GWe a year. However, they are currently operating at less than half of their capacity.

We think it is obvious that electricity can help solve the nation's energy problem. However, over the past seven years the nation's annual electrical growth has decreased from about seven per cent to less than three per cent. Although we must continue to conserve all forms of energy, we can see that we should have been substituting electricity where possible for the growth we have experienced in oil imports.

While electricity load growth has been down because of needed conservation and economic conditions, there are two major obstacles to increased use of electricity; a deteriorating financial position of our electric utilities, and inordinately long construction times for new facilities. These conditions have delayed the conversion from oil and gas-fired generating facilities to solid fueled plants (coal and nuclear), and reduced the incentives for increased electrification in areas highly dependent on oil. These obstacles to replacement of oil by electrification are man-made. As such, they can be solved if we have the will.

While regulatory obstacles to electrification remain, the economic incentive for more electricity capacity and use is increasing. The price of oil is now high enough that new coal and nuclear generating plants can replace oil-fired plants at no increase in the cost of generation.

If the substitution of electricity is to become a major factor in helping to displace easily interruptible imported oil, then coal-based technologies and light water reactors must proceed in a safe but deliberate manner. On that basis, I believe breeder reactor development should continue. I agree with the recent views on the breeder expressed by DOE Secretary Edwards. I agree Clinch River should be continued. We need the experience of building and operating this intermediate size plant to show where designs and component manufacturing processes are appropriate, and where they should be improved. We must not stop there. Unless the experience and the skills gained from it are used, they will atrophy. The step from Clinch River to a plant of near-economic size is a large step, one to be taken with fresh experience and well-tested skill -- not designed from a handbook left by an earlier generation.

It is not too soon to plan that next step now. At some unknown point in time the nation must choose between high cost uranium and breeders. What will be needed then is the industrial capability to build them in adequate numbers to assure reliable performance. While the time available is a subject of debate, proceeding with an expeditious schedule now is the best assurance this capability will be available when needed.

I believe a commitment should be made to design and eventually construct a large developmental plant. The LMFBR base R&D program should be focused on the requirements of that plant. The program should incorporate the lessons learned from the Three Mile Island accident, especially in increased attention to human factors engineering-improved design of the man-machine interface with emphasis on the early real time simulation of the plant control system. We should continue to seek confirmation of component designs such as reactor internal components and improvements in areas thought to have potential for forced outages or undue maintenance. Increased attention should be devoted to the development of the LMFBR fuel cycle with roles for industry in development and systems engineering. We should not wait again to put fuel cycle technology in service until it is economic, only to have an uninformed public told the technology does not exist.

In summary, we believe electricity is an assured substitute for much of the imported oil which threatens our national security and economic health. In producing that electricity, we believe nuclear energy is an essential option. To assure the continuing availability of that source for future generations, the nation should proceed with the disciplined, determined development of the Liquid Metal Fast Breeder Reactor.

Thank you.

## BIOGRAPHY

## ROBERT B. RICHARDS

Dr. Richards is General Manager, Advanced Reactor Systems Department, Sunnyvale, California.

He joined the Research Laboratory of General Electric in 1947 and later that year transferred to the Hanford Atomic Laboratory where he served in a variety of managerial positions. In 1957 he transferred to the Hanford Atomic Power Equipment Department at San Jose, California as Manager, Engineering. He was responsible for engineering development and design of BWRs in the transitional decade leading to competitive nuclear power. In 1968 he assumed management of all fuel and design activities as Manager, Reactor Fuels and Reprocessing and was appointed Manager, International Business Development in 1973, responsible for overseas technical licensing, exchange agreements, joint ventures, etc. He assumed his present position in 1974 where he now has general responsibility for the research development and demonstration of all non-LWB advanced nuclear fission reactor systems, including both the Liquid Metal Fast Breeder Reactor and the High Temperature Gas Cooled Reactor.

Dr. Richards was graduated from Pennsylvania State University with a B.S. in chemical engineering and an M.S. and Ph.D in organic chemistry. He is a member of the National Academy of Engineering, Fellow ANS, Fellow AIChE, R. E. Wilson Award, AIChE and is a Professional Engineer in the state of California.

2/25/81

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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## MONDAY, MARCH 16, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 9 a.m., in room 2318, Rayburn House Office Building, Hon. Howard Wolpe presiding.

Present: Representatives Wolpe, Forsythe, Lujan, and Volkmer.

Mr. **Wolpe**. The subcommittee hearing will come to order.

Let me, first of all, welcome all of you here this morning.

I am Howard Wolpe, serving on the Subcommittee on Energy Research and Production, and I will be chairing this hearing this morning for my colleague, Marilyn Lloyd Bouquard.

I regret we must deal with three important programs of the Department of Energy in this 3-hour session, but this compressed hearing schedule is required to meet the congressionally mandated budgetary schedule.

I am pleased to have here representatives of the Department of Energy as well as two industrial representatives whose testimony will follow. We expect to hear general descriptions of the programs in electrical energy systems, energy storage systems and small-scale hydropower.

We expect to come to an understanding of the rationale and justification for eliminating the program in hydropower, and drastically reducing the level of funding for research in electric energy systems and energy storage systems.

We expect to learn what is being lost and what is being retained. It is my understanding that much of the work being eliminated is long-range research and that industry will be unable to fill the resulting vacuum which, in the long run, could result in importation of advanced technology.

I am also concerned that the elimination of a large measure of academic research in these fields will put the United States proportionately further behind Japan, the Soviet Union, and Western Europe in development of energy manpower that can keep our technology healthy and competitive.

I am pleased to welcome Dr. Maxine Savitz, Assistant Secretary for Conservation, U.S. Department of Energy, who will be our first witness.

Let me inquire of the gentleman from New Jersey whether he wishes to make any opening statement.

Mr. **Forsythe**. No, thank you, Mr. Chairman.

Mr. **Wolpe**. Dr. Savitz, your testimony, of course, will be entered into the record in full.

## STATEMENT OF MAXINE SAVITZ, DEPUTY ASSISTANT SECRETARY FOR CONSERVATION, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY JAMES FURSE, DIRECTOR, DIVISION OF HYDROELECTRIC DEVELOPMENT; JOHN J. BROGAN, DIRECTOR, OFFICE OF ADVANCED CONSERVATION TECHNOLOGIES; KENNETH W. KLEIN, DIRECTOR, ELECTRIC ENERGY SYSTEMS DIVISION

Ms. **Savitz**. Thank you, Mr. Chairman and members of the subcommittee. I appreciate the opportunity to appear before you today.

With me on my left is John Brogan, who is head of the Office of Advanced Technologies under which the Energy Storage and Electric Energy Systems reports.

On my right is Kenneth Klein, who is responsible for Electric Energy Systems and to his right, Jim Furse, who is responsible for the small hydroelectric program.

Within the past 2 weeks, the Electric Energy Systems has been transferred to the Assistant Secretary for Conservation and Renewable Energy from the Assistant Secretary for Resource Applications, which has been disbanded.

I will highlight a few comments from my testimony and submit the whole one for the record.

As you are aware, the President has launched a new beginning in Government which is designed to reduce Federal spending to a level consistent with our ability to support it.

Additionally, the President intends to eliminate regulations that are unneeded or that impose too great a burden relative to the benefit expected. The President's change in direction is reflected in the budget request submitted on March 10, 1981, and in our selection of programs that should continue to receive Government support.

Additionally, the President's program emphasizes the lifting of unnecessary regulations on energy consumption. With energy price decontrol and the deregulation of energy consumption, the private sector can be expected to be much more active in the area of energy conservation. This free market activity should be enhanced by the administration's continuing support of energy tax credits and new initiatives, such as accelerated depreciation for capital equipment.

It is only in the areas where the private sector cannot be expected to respond that the Federal Government should become involved. One such area is long-term generic research and development, where the risks are large and the payback period is long. The administration believes that this kind of research and development deserves continuing support even in periods of severe budgetary constraints.

It is with this philosophical framework in mind that we have changed the direction of certain programs.

I will now describe that new direction.

First is a small-scale hydropower program. The goals of the hydropower program have been to reestablish a vigorous small hydropower industry in the United States. The philosophy has been that the Federal Government would step-in to reawaken interest in this resource and then step out, leaving development to non-Federal sectors.

Specific program objectives are to: Assess the resources potential; develop cost-reduction techniques for small hydro technology; demonstrate immediate commercial feasibility; reduce front-end financial risks for developers; and reduce regulatory and environmental barriers at the Federal and State levels.

As a result of these constraints, the most significant hydropower developments undertaken in recent years have been by the Federal Government through the U.S. Army Corps of Engineers and the Water and Power Resources Service—Department of the Interior.

The Department's small hydro program has served to stimulate a resurgence of a State and local government and private interest in exploiting this attractive resource and to resuscitate an essential quiescent industry. Our activities have helped to alleviate technical and nontechnical constraints and to create an economic, legal, and institutional climate more conducive to the development of the resource by these sectors.

We have developed an up-to-date assessment of small hydro resource base which has been largely carried out by the Corps of Engineers. We expect their new study to indicate, for example, that there are over 1,000 prime existing dams up to 30 MW size that could be retrofitted to produce 7,600 MW of capacity.

Our next important activity was to work cooperatively with developers to demonstrate renewed economic feasibility in the context of today's changing energy market, as well as today's institutional and environmental constraints. We initiated a demonstration program and presently have 20 demonstration projects underway.

These demonstrations were selected to prove the economic feasibility of small hydro in a number of different areas under differing circumstances and to stimulate the domestic hydropower equipment industry.

The DOE share totals $27 million out of an overall estimated cost of $212 million. The 20 projects will bring 134 MW of power on line by the end of 1985.

Because small hydro projects are capital intensive, they require a long leadtime before revenue generation, and are only beginning to emerge as economically competitive with conventional power production. The front-end financial risks have been substantial.

To help ameliorate this, Congress authorized the feasibility and licensing loan program of the Public Utility Regulatory Policies Act of 1978. The program provides loans up to $50,000 each for feasibility studies.

To qualify, projects must be at existing dams and have a capacity between 100 kW and 30,000 kW. A loan may be canceled if a project is found not to be feasible.

The program became operational in April 1980. To date we have received about 350 applications. About two-thirds have been reviewed and 150 loans or loan offers have been made. These contracts have a total face amount of $5,873,000.

In most areas of the country, low rates paid for electricity produced by small-scale facilities have added to the financial risk of development. However, FERC, pursuant to title II of PURPA, has provided what we believe will be a significant boost for the reestablishment of the small hydro industry by developing a sound procedure for States to follow in determining attractive rates.

Because hydropower is a mature technology, DOE research and development efforts, outside the environmental area, have been limited to cost-reduction techniques and a few highly specialized applications. We are, for example, examining the use of pumps as low-cost turbines.

We believe that the States need to exert a leadership role if the small hydropower development potential is to be realized. State and developer related activities of the hydro program are being implemented in the field by the DOE regional offices. Through these efforts, we have encouraged the States to simplify their procedures, identify potential sites and, in turn, encourage developers to undertake projects.

The objectives of the small hydropower program have largely been achieved as evidenced by the rapid increase in the number of license applications before FERC. As a result, we are not requesting any additional appropriations for this program. This does not imply a phaseout of Federal involvement in small hydro. To the contrary, there will still be strong Federal incentives for continued development of hydropower.

These include:

Realistic energy pricing policies, such as the decontrol of domestic crude oil prices which increase the economic attractiveness of small hydro;

A 21-percent investment tax credit for private hydropower projects;

Credit assistance through U.S. Department of Agriculture programs for publicly owned hydropower projects, and

Deregulation of small hydro through the raising of the threshold of projects partially exempt from FERC jurisdiction.

These actions will insure a continued strong hydropower program in the United States without direct spending programs in the DOE budget.

I would like to turn now to the energy storage research and development, which serves as the nucleus for virtually all research and development related to energy storage within the Department. The program supports the end-use sectors in our conservation program and also the renewable energy programs.

The program goal is to help industry provide the technologies required to supply reliable, low cost, safe, and environmentally acceptable energy storage systems. The mechanism used to attain this goal are primarily cost-sharing contracts with industry on advanced storage technologies and more fundamental research.

In addition, we draw on the vast resources of our national laboratories, other government agencies, agreements with foreign governments, and the university, and technical communities.

While this research program supports many other energy supply and end use programs, one useful way to categorize its recent accomplishments is by ultimate end use. The following summarize the accomplishments of our development of energy storage technologies:

For Transportation Technologies:

Battery researchers from national laboratories and industry are close to achieving program goals in battery performance in vehicles. The batteries being developed include: Nickel/zinc; nickel/iron; zinc/chlorine, and improved lead acid. Performance goals range from 41 to 69 Wh/kg—energy density or range—for up to 1300 cycles lifetime, depending on the battery type.

The National Battery Test Laboratory, where cells and modules developed by research teams undergo verification testing, now operates on a continuous basis.

A prototype aluminum/air cell, whose mechanical recharge feature is similar to gasoline refueling, has been successfully tested at full size with a recrystallizer that removes the products formed on battery discharge. It has an energy density of 340 Wh/kg.

For building heating and cooling technologies, we have done some design and fabrication of a 10 kWh prototype superconducting energy storage magnet, for power stabilization in the Bonneville Power Administration grid.

For industrial technologies:

A 200 kW prototype electolyzer system using 2.5 foot 2 solid polymer electrolyte cells has been assembled and tested.

An analytical study is underway to define whether customer-owned battery storage for industrial and small business areas would achieve a significant peak electric demand reduction and thus an oil saving.

There are two program areas in the storage program. For the electrochemical storage area the request is $26.25 million and for the physical and chemical storage we are requesting $12.25 million. The program direction request is $0.50 million.

The electrochemical energy storage area includes:

Technology base and supporting research projects on electrolytes, electrodes, electrochemical materials, fuel cells, and electrochemical process fields.

Evaluation of metal-air battery modules and fuel cells, and fuel cells for electrochemical process fields.

Evaluation of metal-air battery modules and fuel cells for mobile applications.

Exploratory technology development in advanced electrochemical systems for load leveling, and applications-oriented research related to dispersed site systems and solar concepts.

In the physical and chemical energy storage emphasis will be placed on:

Thermal energy storage technology base development;

Chemical heat pump development;

Flywheel materials research;

Underground storage supporting research; and

Reservoir stability.

The electrical energy network provides energy to all sectors of the economy for a variety of different purposes, including an indispensable power link during national emergencies and for national defense. Because the electric network is so reliable, it frequently is taken for granted. It is only in a brownout or emergency that we even think about it.

The goals of the EES program function are to evaluate electric network problems from a systems perspective and to undertake longer term, high-risk research to meet the future needs of the system. No other program in the Federal Government shares this responsibility. To accomplish this, EES has five major objectives:

Perform a long-term system architecture function to help successfully integrate into the electric power system large remote generating facilities with new electric sources that are frequently intermittent and unpredictable;

Reduce system losses through research on advanced transmission and distribution technologies;

Improve the long-term national electrical system efficiency, reliability, and adaptability under normal and emergency conditions by the use of advanced control system technology;

Protect the environment by performing research on the impacts and harmful effects of high voltage electric fields; and

Improve system load factor.

Our efforts are concentrated on the systems approach because the experience to date shows that we can achieve overall economy, efficiency, and reliability only by integrating generation, transmission, distribution, and utilization of electric energy into one comprehensive system.

The accomplishments of the EES R&D program span hardware, software, studies, and assessments. By the end of fiscal year 1981 we expect these accomplishments:

Completed first significant field test of a 100 meter single conductor superconducting cable;

Completed small animal biological tests on the effects of high-intensity electric fields on living organisms. Some effects have been identified, but do not as yet indicate that they pose a risk to humans;

Fabricated components at MIT for an advanced superconducting generator;

Completed advanced two-way distributed systems communication tests that required and received a major shift in A.T. & T. Bell System policy, and uncovered specific needs for future development;

Completed the conceptual design of a high-voltage ac prototype circuit breaker;

Completed a test on the effect of carbon fibers on electrical systems and equipment, finding no adverse effects.

The DOE requested fiscal year 1982 EES budget is $9.9 million. The program has divided this funding into $4.1 million for system architecture and integration program activities; $4.9 million for power delivery, and about $0.9 million for program direction. This will enable critical high-risk research activities to be performed while transferring all the near-term demonstration and feasibility evaluations to the private sector.

R. & D. priorities to determine the impacts of dispersed sources, storage, and end-use management on system load profiles. These research priorities are also directed toward distribution system design and protection to provide a first level of worker safety measures on lines integrated with new generating devices.

Modern validation to conceptualize the dynamic system performance of new electric technologies.

Mathematical representations of more complex control concepts.

Under power delivery, the program will concentrate on:

Basic research on advanced dielectric materials for future advanced cables;

Development and testing of an advanced concept for a.c.-d.c. circuit breaker and pursuit of generic concepts for high-voltage d.c. systems.

Biological studies on the electric field effects on small animals and biological tissue investigation.

These activities will enable critical high-risk research activities to be performed while transferring all the near-term demonstration and feasibility evaluations to the private sector.

This concludes the formal highlights that I would like to present, and we would be pleased to try to respond to any questions that the committee might have.

[The prepared statement of Ms. Savitz follows:]

STATEMENT OF

DR. MAXINE SAVITZ
DEPUTY ASSISTANT SECRETARY FOR CONSERVATION
CONSERVATION AND RENEWABLE ENERGY
DEPARTMENT OF ENERGY

Before the

SUBCOMMITTEE ON ENERGY RESEARCH
AND PRODUCTION

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

March 16,1981

Mr. Chairman and members of the Subcommittee:

I appreciate the opportunity to appear before you today to provide testimony regarding the energy conservation programs of the Office of Conservation and Renewable Energy involving energy storage, electrical energy systems, and small-scale hydropower.

As you are aware, the President has launched a new beginning in Government, which is designed to reduce Federal spending to a level consistent with our ability to support it. Additionally, the President intends to eliminate regulations that are unneeded or that impose too great a burden relative to the benefit expected. The President's change in direction is reflected in the budget request submitted on March 10, 1981,and in our selection of programs that should continue to receive Government support.

The first step in this change in direction was the President's immediate decontrol of oil prices. This action was taken in the belief that realistic energy prices will do more for energy conservation than governmental conservation programs. Additionally, the President's program emphasizes the lifting of unnecessary regulations on energy consumption. With energy price decontrol and the deregulation of energy consumption, the private sector can be expected to be much more active in the area of energy conservation. Further, this free market activity should be enhanced by the administration's continuing support of energy tax credits and new initiatives, such as accelerated depreciation for capital equipment.

It is only in the areas where the private sector cannot be expected to respond that the Federal Government should become involved. One such area is long-term, generic research and development, where the risks are large and the payback period is long. The Administration believes that this kind of research and development deserves continuing support even in a period of severe budgetary constraints.

It is with this philosophical framework in mind that we have changed the direction of certain of our programs. I will now describe that new direction.

## SMALL-SCALE HYDROPOWER PROGRAM

### Goals and Objectives

The goals of the hydropower program has been to re-establish a vigorous small hydropower industry in the United States. The strategy has been that the Federal Government would "step in" to re-awaken interest in this resource and then "step out," leaving development to non-Federal sectors.

Specific program objectives are to: assess the resources potential; develop cost-reduction techniques for small hydro technology; demonstrate immediate commercial feasibility; reduce front-end financial risks for developers; and reduce regulatory and environmental barriers at the Federal and State level.

The small hydro program was begun in 1977 in response to the need to increase our national energy supplies, diversify energy sources, and lessen our dependence on imported oil. Hydro was considered a prime candidate for development in that it is domestic, widely dispersed, renewable, nonpolluting, and relatively benign in terms of its environmental impacts. It is also a mature technology and the many small sites, collectively, are capable of making a significant supply contribution in the near term.

At that time, the small hydro industry had been in a depressed state as a result of decades of decline in the use of waterpower for electric power generation, particularly at small sites. Thousands of hydroelectric plants have been abandoned in the past because of their inability to compete with low-cost oil prices and large central station thermal plants. Increases in oil prices are helping stimulate a rebirth of interest in the hydropower resource, but years of neglect have created a serious shortcoming in our institutional, technical, and financial capability to assure a renewal of the industry.

As a result of these constraints, most significant hydropower developlments undertaken in recent years have been by the Federal Government through the U.S. Army Corps of Engineers and the Water and Power Resources Service (Interior).

## Program Benefits

The Department's small hydro program has served to stimulate a resurgence of a state, local government, and private interest in exploiting this attractive resource and to resuscitate an essential quiescent industry. Our activities have helped to alleviate technical and nontechnical constraints and to create an economic, legal, and institutional climate more conducive to the development of the resource by these sectors.

## Recent Accomplishments

Developing an up-to-date assessment of small hydro resource base has been largely carried out by the Corps of Engineers. We provided funds to enable the Corps to assess the small-scale potential and make this information available to interested developers. An initial assessment has been published and widely distributed, and the Corps is now revising and refining that assessment. We expect their new study to indicate, for example, that there are over 1,300 prime existing dams up to 30 MW size that could be retrofitted to produce 7,600 MW of capacity.

Our next important activity was to work cooperatively with developers to demonstrate renewed economic feasibility in the context of today's changing energy market (as well as today's institutional and environmental constraints).We initiated a demonstration program and presently have 20 demonstration projects underway. These demonstrations were selected to prove the economic feasibility of small hydro in a number of different areas under differing circumstances and to stimulate the domestic hydropower equipment industry.

The DOE share totals $27 million out of an overall estimated cost of $212 million. The 20 projects will bring 134 MW of power online by the end of 1985.

Because of small hydro projects are capital-intensive, require a long leadtime before revenue generation, and are only beginning to emerge as economically competitive with conventional power production, the front-end financial risks have been substantial. To help ameliorate this situation, Congress authorized the feasibility and licensing loan program in Title IV of the Public Utility Regulatory Policies Act of 1978 (PURPA). The program provides loans up to $50,000 each for feasibility studies and for expenses incurred in obtaining a Federal Energy Regulatory Commission (FERC) license and other required permit. To qualify, projects must be at existing dams and have a capacity between 100 kW and 30,000 kW. A loan may be canceled if a project is found not to be feasible. Otherwise, repayment must be made over 10 years, beginning 4 years after the loan is made.

The program became operational in April 1980. To date we have received about 350 applications. About two-thirds have been reviewed, and 150 loans or loan offers have been made. These contracts have a total face amount of $5,873,000.

We believe that significant progress has also been made in the mitigation of restrictive Federal and State laws, procedures, and environmental requirements. Through research contracts with the John Hopkins University and the Franklin Pierce Law Center, legal and institutional impediments have been identified and solutions recommended. Utilizing the findings of the studies, we have funded the National Conference of State Legislatures to provide technical support for State legislatures in implementing legislation and procedures to minimize regulatory and other barriers. We have also worked closely with FERC to improve and expedite the Federal permitting and licensing process.

In most areas of the country, low rates paid for electricity produced by small-scale facilities have added to the financial risk of development. However, FERC, pursuant to Title II of PURPA, has provided what we believe will be a significant boost for the re-establishment of the small hydro industry by developing a sound procedure for States to follow in determining attractive rates. Regulations have been published requiring each State public utility commission (PUC) to establish rates using the avoided or marginal cost concept. The Franklin Pierce Law Center's Energy Law Institute, with funding and direction from DOE, has provided technical assistance to the State PUC's in this effort. When such rates are in place, they should serve as an important aid in helping small power producers negotiate favorable power-purchase contracts with their local public utilities.

In the environmental area, the cost of fish transport facilities, for example, when added to the cost of retrofitting dams for power generation, could make projects economically infeasible. Meeting requested minimum streamflow requirements below the projects could have a similar impact. DOE is funding research to provide technical and cost guidance for developers and to resolve issues between FERC and the U.S. Fish and Wildlife Service on minimum streamflow requirements.

Because hydropower is a mature technology, DOE research and development efforts, outside the environmental area, have been limited to cost-reduction techniques and a few highly specialized applications. We are, for example, examining the use of pumps as low-cost turbines. Another research activity involves 12 conceptual studies and one field test for ultra low-head applications (less than 10 feet).

We believe that the States need too exert a leadership role if the small hydropower development potential is to be realized. State and developer-related activities of the hydro program are being implemented in the field by the DOE regional offices. Through these efforts, we have encouraged the States to simplify their procedures, identify potential sites, and, in turn, encourage developers to undertake projects.

## Proposed Program

The objectives of the small hydropower program have largely been achieved as evidenced by the rapid increase in the number of license applications before FERC. As a result we are not requesting any additional appropriations for this small-scale hydropower program. This does not imply a phase-out of Federal involvement in small hydro. To the contrary, there will still be strong Federal incentives for continued development of hydropower. The major elements of this involvement include:

- realistic energy pricing policies, such as the decontrol of domestic crude oil prices, which increase the economic attractiveness of small hydro

- A 21 percent investment tax credit for private hydropower projects.

- Credit assistance through U.S. Department of Agriculture programs for publiclyowned hydropower projects.

- Deregulation of small hydro through the raising of the threshold of projects partially exempt from FERC jurisdiction to 15 MW.

These actions will ensure a continued strong hydropower program in the United States without the need for direct spending programs in the DOE budget.

# ENERGY STORAGE RESEARCH AND DEVELOPMENT

## Introduction

The Energy Storage Research and Development Program serves as the nucleus for virtually all research and development related to energy storage within the Department. The program supports the end-use sectors in our Conservation program and also the Renewable Energy programs.

## Program Goals and Objectives

The program goal is to help industry provide the technlogies required to supply reliable, low-cost, safe, and environmentally acceptable energy storage systems. The mechanisms used to attain this goal are primarily cost-sharing contracts with industry on advanced storage technologies and more fundamental research. In addition, we draw on the vast resources of our national laboratories, other Government agencies, agreements with foreign Governments, and the university and technical communities.

## Benefits

The research sponsored by the Energy Storage Research and Development Program provides a firm technology base on which industry can proceed with its developments of new, energy-efficient, and renewable products. Implementation of this strategy requires close coordination with applied research laboratories in industry as well as with academia in order to ensure that the research being undertaken is supportive of industry, that our efforts do not duplicate those of industry, and that, as a result of our work, we neither supplant nor lessen industry research efforts. The benefits of cost-effective energy storage technologies are: increased energy productivity; increased substitution of coal, nuclear, and renewables for petroleum and natural gas; increased use of renewable but intermittent energy sources, and increased effectiveness of baseload electric power generating and distribution capacity.

## Recent Program Accomplishments

While this research program supports many other energy supply and end-use programs, one useful way to categorize its recent accomplishments is by ultimate end-use. The following summarized the accomplishments of our development of energy storage technologies:

For Transportation Technologies:

- Battery researchers from national laboratories and industry are close to achieving program goals in battery performance in vehicles. The batteries being developed include: nickel/zinc, nickel/iron, zinc/chlorine, and improved lead-acid. Performance goals range from 41 to 69 Wh/kg (energy density or range) for up to 1300 cycles (lifetime), depending on the battery type.
- The National Battery Test Laboratory (NBTL), where cells and modules developed by research teams undergo verification testing, now operates on a continuous basis.
- A prototype aluminum/air cell (whose "mechanical" recharge feature is similar to gasoline refueling) has been successfully tested at full size with a recrystallizer that removes the products formed on battery discharge. It has an energy density of 340 Wh/kg.

For Building Heating and Cooling Technologies:

- Life and stability tests of experimental phase-change materials in unique packages have been performed, and the phase-change materials were used in an air-conditioning field test.
- Prototype design and economic studies for a sulfuric acid-water chemical heat pump have been completed, and a residential-size salt-alcohol system has been constructed.
- A laboratory-size hybrid chemical heat pump has been successfully tested, and a rapid cycling system using waste heat has proceeded into further development.

For Solar and Conventional Utilities Technologies:

- In the exploratory electrochemical technology area, experimental sodium/sulfur cells now exhibit 500-900 cycles (vs. a goal of 2000 for load-leveling), and a zinc/bromine module storing 80 kWh (a convenient size for load-leveling plants) has been assembled for laboratory evaluation.
- Design and fabrication of a 10 kWh prototype superconducting energy storage magnet have been completed for power stabilization in the Bonneville Power Administration grid.

For Industrial Technologies:

- A 200 kW prototype electrolyzer system using 2.5 $ft^2$ solid polymer electrolyte cells has been assembled and tested.
- An analytical study is underway to define whether customer-owned battery storage for industrial and small business areas would achieve a

significant peak electric demand reduction and thus an oil saving.

- To reduce energy consumption in electrolytic process industries, air cathodes (for chlor-alkali) and hydrogen anodes (for zinc refining) are being experimentally developed and tested in full-size electrolytic cells.

## Proposed Program

There are two program areas in the storage program. For the Electrochemical Storage area the request is $26.25 million and for the Physical and Chemical Storage we are requesting $12.25 million. The program direction request is $0.50 million.

The emphasis in the program will be on developing the technology base needed for industry's research and development effort and on long-term research and development since nearer term storage technologies will be developed by the private sector as the market develops. Areas that will continue to receive emphasis in the Electrochemical Energy Storage area include:

- Technology base and supporting research projects on electrolytes, electrodes, electrochemical materials, fuel cells, and electrochemical process fields.
- Evaluation of metal-air battery modules and fuel cells, and fuel cells

for electrochemical process fields.

- Evaluation of metal-air battery modules and fuel cells for mobile applications.
- Exploratory technology development in advanced electrochemical systems for load-leveling.
- Applications-oriented research related to dispersed site systems (customer-side-of-the-meter-systems) and solar concepts.

In the Physical and Chemical Energy Storage emphasis will be placed on:

- Thermal energy storage technolgy base development.
- Activities aimed at appplications in buildings.
- Chemical heat pump development.
- Flywheel materials research.
- Underground storage supporting research.
- Reservoir stability experiments with compressed air.
- Stabilizing magnet development.

## ELECTRIC ENERGY SYSTEMS

### Introduction

The electrical energy network in the United States Provides energy to all sectors of the economy for a variety of different purposes--including an indispensable power link during national emergencies and for national defense. Because the electric network is so reliable, it frequently is taken for granted.

In addition, the system must be more efficient to control costs. Transmission losses are inherent in all systems. Electric system losses consume about 220 billion kilowatt hours per year, equivalent to 380 million barrels of oil per year. Much of these losses can be attributed to low voltage equipment--primarily transformers and conductors.

As a result of crude oil price decontrol and other Federal incentives, diversified electric sources--both conventional and renewable--will increase their share of electrical energy supply to support future U.S. economic growth. It is seldom mentioned that new dispersed facilities, when integrated with conventional large-scale plants, require advanced control methods and new network designs. To accomplish this, an advanced transmission and energy distribution system is required with different characteristics from those that exist today.

### Goals and Objectives

The Electric Energy Systems (EES) principal function is to evaluate electric network problems from a "systems" perspective and to undertake longer term, high-risk research to meet the future needs of the system. No other program in the Federal Government shares this responsibility. To accomplish this, EES has five major objectives:

- Perform a long-term "system architecture" function to help successfully integrate into the electric power system large remote generating facilities with new electric sources that are frequently intermittent and unpredictable.

- o Reduce system losses through research on advanced transmission and distribution technologies.
- o Improve the long-term national electrical system efficiency, reliability, and adaptability under normal and emergency conditions by the use of advanced control system technology.
- o Protect the environment by performing research on the impacts and harmful effects of high voltage electric fields.
- o Improve system load factor through advanced control concepts.

Our efforts are concentrated on the "systems" approach because the experience to date shows that we can achieve overall economy, efficiency, and reliability only by integrating generation, transmission, distribution, and utilization of electric energy into one comprehensive system.

## Benefits

Advanced electric system equipment and analytical tools have a great potential in fostering adoption of new technologies and remote baseload plants into the electric network. This integration function includes wind, photovoltaics, ocean thermal, storage, and distributed end-use technologies. There are also significant advances from EES research in automatic controls for bulk power delivery from large remote nuclear and coal plants. This research on electric energy systems can be applied to improved operating characteristics of utilities throughout the United States.

Various options for transmitting large blocks of energy utilizing underground d.c. transmission systems are being evaluated in a contract with Philadelphia Electric Company. This follows a previous effort with Philadelphia Electric, which was instrumental in focusing R&D attention on three cable systems--compressed gas, a.c. superconducting, and high voltage d.c. insteadd of the several dozen previously funded.

Program Accomplishments

The accomplishments of the EES R&D program span hardware, software, studies, and assessments. By the end of FY 1981 we expect these accomplishments:

- Completed first significant field test of a 100 meter single conductor superconducting cable.
- Started full-scale laboratory test of ± 600 kV dc cable, having completed test prototype.
- Developed a laboratory model compact gas-insulated transformer that will be 60 percent smaller and have 20 percent less energy loss than current transformers.
- Completed small animal biological tests on the effects of high-intensity electric fields on living organisms. Some effects have been identified, but do not as yet indicate that they pose a risk to humans.
- Fabricated components at M.I.T. for an advanced superconducting generator.
- Demonstrated the effects on distribution systems of heating and cooling storage, including the Olympic Village in Lake Placid, New York.
- Completed advanced distribution system design and protection studies, which identified requirements necessary to protect utility and customer equipment from reverse power flow and other intrinsic characteristics of new technologies integrated into operating systems. The study also

focused on areas of basic research for distributed generation and end-use management in electric distribution systems.

- Completed the software for an advanced automatic generation control project at the Wisconsin Electric Power Company providing new concepts for coordinated utility system resource control.
- Completed advanced two-way distributed systems communication tests that required and received a major shift in AT&T Bell System policy, and uncovered specific needs for future development.
- Completed the conceptual design of a high-voltage a.c. prototype circuit breaker.
- Completed a test on the affect of carbon fibers on electrical systems and equipment, finding no adverse effects.

Proposed Plans

The DOE requested Fy 1982 EES budget is $9.9 million. The program has divided this funding into $4.1 million for system architecture and integration program activities, $4.9 million for power delivery, and about $0.9 million for program direction. This will enable critical high-risk research actiivites to be performed while transferring all the near-term demonstration and feasibility evaluations to the private sector.

- R&D priorities to determine the impacts of dispersed sources, storage, and end-use management on system load profiles. These research priorities are also directed toward distribution system design and protection to provide a first-level of worker safety measures on lines integrated with new generating devices.
- Model validation to conceptualize the dynamic system performance of new electric technologies.
- Mathematical representations of more complex control concepts during

both emergency and normal operating conditions that include control hierarchies for systems with remote central stations and dispersed generation and storage devices.

Under Power Delivery, the program will concentrate on:

- Basic research on advanced dielectric materials for future advanced cables.
- Development and test of an advanced concept for a d.c. circuit breaker and pursuit of generic concepts for high-voltage d.c. systems.
- Biological studies on the electric field effects on small animals and biological tissue investigation on cells and cultures.
- Basic and fundamental studies of insulation and dielectric materials for high-voltage a.c. electric energy applications, with evaluations of alternative electric energy delivery options employing advanced a.c. and d.c. transmission.

These activities will enable critical high-risk research activities to be performed while transferring all the near-term demonstration and feasibility evaluations to the private sector.

## PARTNERSHIP WITH INDUSTRY

As the program levels in the Department's revised FY 1982 budget for solar and other renewable energy technologies reflect, we are embarked on a new course regarding the appropriate Federal role in energy development. Quite simply stated, this budget explicitly eliminates excessive Federal involvement in solar and other renewable energy development. Concomitantly, this revised request contains as implicit redirection as well--a closer partnership with industry. I would now like to explore with you two aspects of this implied redirection.

## Clarification of Roles

In the past, the Department's energy technology programs were not clear on the appropriate role to be played by the Federal sector in technology development. Program managers were responsible for the entire spectrum of technology development and transfer from research, development, demonstration, through commercial deployment. The Government role and relationship between industry and Government were not clearly defined. Government perceived that specific technologies such as solar and geothermal were not being developed as rapidly as possible due to high technology risks and large front-end capital investments. On the other hand, industry perceived that Government might subsidize demonstration or near-commercial hardware projects with the result that necessary investments were delayed, thereby creating the climate for a very real market failure. In Conservation and Renewable Energy, past emphasis on technology development was oriented toward end-use applications rather than supply-side technology development. Not surprisingly, industry played a secondary role in all phases of technology development as a result.

The revised FY 1982 budget before you today, in addition to recent organizational realignments along fuel or supply-side lines within the Department, clearly sorts out and delineates the appropriate roles to be played both by industry and Government in solar and renewable energy technology development. As I attempted to convey at the outset of my testimony today, the Administration believes strongly that Government should focus only on longer term reseaarch and development projects that are too risky for private firms to undertake; industry will be expected to support development and demonstration of promising near-term solar and renewable energy technologies and be responsible for their ultimate commercial deployment.

Therefore, as a result of this clarification of roles, both Government and industry can now better concentrate their separate efforts and scarce resources on areas where their respective comparative advantages are best suited.

## Cooperation and Integration of Efforts

This redirection and clarification of roles, however, does not mean that industry and Government should proceed in the blind as each pursues its separate role in the development of the various solar and renewable energy technologies. Quite the contrary; the need for close cooperation and integration of planning efforts will be even greater today.

To facilitate such cooperation and integration in the future, we are presently evaluating methods by which Government-funded research and development in solar and other renewable energy technologies can best be transferred to the private sector. In addition, we are exploring new approaches and forums for integrating Government planning efforts with those of industry. Accordingly, it is our goal that industry be treated as an equal partner in solar and other renewable energy technology development rather than as a contractor or subcontractor as had previously been the case.

Mr. Chairman, this concludes my formal statement. I would be pleased to respond to any questions that either you or the other members of the Subcommittee may have regarding the Department's FY 1982 budget for energy storage, electric energy systems and small-scale hydropower.

BUDGET HISTORY

(in millions)

| (Energy Storage) | Fy 1981 Base | Budget Jan. 15 | FY 1981 Current | Current Congress | Change FY 1981 | Change FY 1982 |
|---|---|---|---|---|---|---|
| Electrochemical | 38.5 | 31.3 | 27.3 | 26.2 | -11.2 | - 5.1 |
| Physical and Chemical | 32.3 | 27.2 | 23.6 | 12.3 | - 8.7 | -14.9 |
| Program Direction | 1.1 | 1.0 | 1.0 | 0.5 | - 0.1 | - 0.5 |
| TOTAL | 71.9 | 59.5 | 51.9 | 39.0 | -20.0 | -20.5 |
| Hydropower | | | | | | |
| Small Scale Hydro Power Dev. | 11.0 | 2.7 | 6.4 | 0 | - 4.6 | - 2.7 |
| Feasibility Studies Loan Program | 10.0 | .0 | -9.9 | 0 | -19.9 | - |
| Program Direction | .8 | .5 | .8 | 0 | 0 | - .5 |
| TOTAL | 21.8 | 3.2 | -2.7 | 0 | -24.5 | - 2.8 |
| Electric Energy Systems | | | | | | |
| Power Delivery | 20.0 | 19.0 | 17.7 | 4.9 | - 2.3 | -14.1 |
| System Architecture & Integration | 19.0 | 12.9 | 16.7 | 4.1 | - 2.3 | - 8.8 |
| Generation & Storage App. | .0 | 6.3 | .0 | .0 | .0 | - 6.3 |
| Program Direction | .9 | .8 | .6 | .9 | - .3 | - .1 |
| TOTAL | 39.9 | 39.0 | 35.0 | 9.9 | - 4.9 | -29.1 |

Mr. **Wolpe**. Thank you very much, Dr. Savitz.

Just one technical point before we get into the broader questioning. You refer early in the testimony to a 21 percent investment tax credit for private hydropower projects. Is that above and beyond the basic energy investment tax credit?

Mr. **Furse**. It is a total of 21. There was another 11 percent added by the Crude Oil Windfall Profits Tax Act, and that was added to the 10 percent that was there already.

Mr. **Wolpe**. That is not uniquely for hydropower? That is the basic energy tax credit you were referring to?

Ms. **Savitz**. That tax credit has certain things specified. All energy related activities are included.

Mr. **Wolpe**. Thank you.

The basic thrust of the rationale that is being presented for some very substantial cuts in this function is that that being eliminated can be picked up by the private sector, and the Government will continue tc be involved with long-term research and development, primarily. Is that correct?

Ms. **Savitz**. That is correct.

Mr. **Wolpe**. If that is the rationale, why are you proposing to discount work on long-term exploratory development of hydrogen technology and large-scale superconducting magnetic energy storage?

Ms. **Savitz**. Well, we made priority assessments of all the long-term work and looked at the flywheel work and some of the chemical heat pump work, and in looking at the priorities and the dollars that were available for the long term work, we felt that the hydrogen work could not be funded at this budget level. We wanted to be able to as completely fund the other programs as possible.

Mr. **Wolpe**. But this is an example, is it not, of work that would fall into the category of long-range research, not near-term commercialization?

Ms. **Savitz**. The hydrogen program is a longer term type of research.

Mr. **Wolpe**. Likewise, with the electric energy systems program, are you not proposing to discount a very substantial amount of long-range research?

Ms. **Savitz**. Some of the projects that will be eliminated will also be longer term. What we will be funding is longer term research, but there are others. Again, going through the priorities relative to the funding available, we had to pick those with the best potential payoff from the information we had.

Mr. **Wolpe**. What evidence do you have that the private sector will pick up the various research elements that are being sacrificed?

Ms. **Savitz**. Well, we have had a fair amount of cost-sharing in many of these programs, particularly the near-term battery work, about 30 percent cost-sharing, and it is felt in some of those the private sector would continue to fund those, as we dropped our funding. It may be at a lower level because they may just still put in the same amount of money.

Mr. **Wolpe**. Could you give us some specific examples of firms that have already indicated an intention to in fact pick up work that is being eliminated?

Ms. SAVITZ. In such work as some of the zinc bromine work that we have been doing with Gould and Exxon, follow on private funding seems probable Exxon has funded about two-thirds of the work. We have funded a third. Exxon will continue.

Mr. WOLPE. Do we know that for a fact?

Ms. SAVITZ. We don't know that for a fact; we are just starting to talk to those industrial contractors to find out how much they wil be picking up.

We will be monitoring over the course of the year exactly which projects are continued and which are not.

Mr. WOLPE. Is it your feeling, I mean is it your feeling really that the basic research and development elements of this program will continue as if nothing had happened with the dimension of the cuts that are being proposed? Will continue at the same rate and level of activity?

Ms. SAVITZ. That it will continue? The private sector might continue their part of it; what we don't know yet is whether they will increase their funding, so that the projects are at the same level. It would stretch out the time.

If we were going to get results in the next 2 years it means we might not get results for 4 years.

Mr. WOLPE. What would that mean in terms of the longer term competitiveness of the industries that are involved in this kind of research effort?

Ms. SAVITZ. Well, there is a lot of foreign activity going on already in all of those, both the electrochemical, electric energy systems work, and also the storage work.

For example, the sodium sulfur battery. The British Government has been funding that for many years, at I guess about $10 million a year. Japan also has been funding that. Those activities will continue, and they could possibly get batteries developed before we do.

In the electric energy systems program, we are currently importing about 40 percent of the equipment we buy now which comes from out of this country. Those activities will continue with potential for more foreign dominance in those markets.

Mr. WOLPE. Is the research in Japan to which you are referring being executed entirely by the private sector or is there a Government component as well?

Ms. SAVITZ. The Japanese, I think, have sort of a tripartite program in some cases with universities and with industry.

In the battery programs, I know that most of the work they are doing related to electric inventions is done by the private sector, but the research that they are doing in flywheels and in some of the sodium/sulfur battery work, that is done by the government with industry.

We can try to provide you for the record some specific dollars for some of those projects.

[The information follows:]

## FOREIGN ACTIVITIES IN SODIUM-SULFUR BATTERY RESEARCH AND DEVELOPMENT

Foreign activities in sodium-sulfur battery research and development involve 184 people and are funded at about $13.5M. The largest of these programs is at Brown-Boveri in the Federal Republic of Germany, where 61 people are engaged in a $6.1M dollar program, funded half by the government and half by Brown-Boveri, to develop both load leveling and electric vehicle batteries. The $1.2M program at CGE in France is also involved in both load leveling and vehicle programs. This program funded by the French government (35%), CGE (35%), General Electric (15%); the Electric Power Research Institute (EPRI) (15%) employs about 15 people.

Development of load leveling batteries is the goal of the $0.9M program at Yuosa Battery Co. in Japan. This program, which employs about 25 people, is funded half by the Japanese government and half by Yuosa. Vehicle batteries are the chief interest of the programs at both British Rail and Chloride Silent Power. The British Rail program involves the work of 21 people and is funded at $1.3M: one-third from the British Ministry of Transportation, one-third by British Rail, and the balance by Chloride Battery Co., Ltd. The $4.0M, 62 person program at Chloride Silent Power receives $1.5M from Chloride Battery Co., $1.5M from the British Electricity Council, and $1.0M from the British Department of Industry.

FLYWHEEL WORK UNDERWAY WORLDWIDE

The Department of Energy is aware of flywheel work for automotive applications being done by at least eight different foreign countries. Those countries are Italy, West Germany, France, Israel, Sweden, United Kingdom, the Netherlands, and Switzerland. The research is mainly aimed at developing flywheels for buses. Of the approximately $10 million being spent worldwide, about half is supported by funding from foreign governments.

Mr. **Wolpe.** Would you do that; I think it would be interesting and helpful to have some understanding of the government role in the energy research and development areas that are under review this morning.

It would be helpful to gain some sense, both in Japan and whatever other countries represent major competitors, or actual competitors within this set of industrial sectors.

Ms. **Savitz.** The German Government has also been quite active in work in the utilities area. They, of course, own a lot of utilities, and so they have been putting research dollars into it.

Mr. **Wolpe.** I want to come back in just a few minutes to some very specific questions related to each of the elements of the program, but my time has expired, so let me now turn to the gentleman from New Jersey, Mr. Forsythe.

Mr. **Forsythe.** Thank you, Mr. Chairman.

Do we have here a list of the ongoing projects which are being funded? I would rather have you supply it for the record rather than take your time this morning. It seems to me we would get a better picture of what you are moving forward with and what you are leaving behind.

Ms. **Savitz.** We received a similar question from the Appropriations Committee last week which we are completing and we can send you the answer to that, which talks about rescissions and deferrals for fiscal year 1981 and also what programs will be funded in 1982, and which programs will not be funded in 1982. We can provide that.

Mr. **Forsythe.** Good.

[The information follows:]

## RESCISSIONS AND DEFERRALS FOR FY 1981

Energy Storage.--The FY 1981 rescission in the Energy Storage Program totals $19.9 million. A rescission in the Thermal Energy Storage subprogram of $2.85 million will cancel the following activities: systems analysis of thermal transport, research on advanced storage concepts, technology development of storage systems to use waste heat through industrial retrofit, and development of high-temperature storage materials at SERI; in addition, development of heat exchanger technology for district heating will be reduced. The Chemical/Hydrogen Energy Storage subprogram is being reduced by $1.85 million because we are planning to terminate the development of an advanced electrolyzer for hydrogen production at General Electric in Massachusetts and the development of hydrogen production by water splitting at General Atomic in California; we are also planning to cancel the demonstration of hydrogen production, storage, distribution, and use at a small hydro facility in New York. Cancellation of low-cost flywheel projects at MIT and a flywheel manufacturing project at Garrett Corporation in California will bring about a reduction of $1.0 million in the Mechanical/Flywheel Energy Storage Subprogram.

In the Underground Energy Storage Subprogram, the underground pumped hydro activity, solar and adiabatic compressed air storage activities at Pacific Northwest Laboratories, and all projects leading to demonstrations at various locations will be canceled to save $1.8 million. A reduction of $0.1 million will be taken in the Mechanical Applications Subprogram in order to reduce the effort in the transfer of compressed air storage work to utilities, performed at Pacific Northwest Laboratories. In the Superconducting Magnetic Energy Storage subprogram, the large-scale utility superconducting magnet program at the University of Wisconsin will be canceled, a reduction of $0.6 million. The Electric Power Research Institute (EPRI) will initiate a feasibility study on the concept without DOE participation. In the Technical and Economic Analysis Subprogram, cost/benefit, applications and market analyses will be canceled at various locations for a reduction of $0.5 million.

Of the total $19.9 million reduction for Energy Storage $11.2 million is from the Electrochemical Energy Storage Subprogram. Among the terminations planned are the dispersed battery application project, which includes the Public Gas & Electric Co. of New Jersey's Battery Energy Test Facility, the purchase of prototype zinc/chlorine batteries to be tested in this facility, and the Storage Battery Electric Energy Demonstration Project. Activities in the near-term mobile application that relate to nickel/zinc and zinc/chlorine modules and to phenomenal studies on zinc electrodes will be reduced. The exploratory technology development activities related to non-aqueous lithium/metal sulfide and sodium/sulfur batteries will be reduced. As a result, prototype modules that had been scheduled for testing in 1982 will not be available until 1984. In addition, research activities in these programs are reduced.

Electric Energy Systems.--The deferrals and rescissions in FY 1981 for Electric Energy Systems total $4.9 million for eight subprogram elements. In New Technology Integration, $319,000 is rescinded in the areas of dynamic systems theory, wind integration, and advanced converter technology. A $200,000 project in energy management in the Distributed Systems Management subprogram will not be funded.

There is a total of $2.086 million reduced or rescinded in the Systems Control and Development subprogram. The projects affected are hierarchical control systems theory, advanced control theory, emergency state theory, dynamic security assessment, three program research and development announcement RFP's, and information/data flow theory work.

The High-Voltage Alternating Current (HVAC) subprogram will be reduced by $378,000 in areas of the 1200 kV semiflex cable, dielectric aging study, graphite fiber conductor work, and high-voltage dielectric work. There are no programmatic impacts from the rescissions in the High-Voltage Direct Current (HVDC) subprogram.

In the Electric Field Effects subprogram, only one project is affected by the rescission, the electric field in-situ measurement work. It has been reduced by $50,000. The Underground Power Transmission subprogram has been reduced by $400,000 in the areas of deep-water submarine cable, VAR control, and transformer options. None of the Storage Applications subprogram has been impacted by a rescission.

A large number of miscellaneous small reductions budgeted in FY 1981 has been reduced by $700,000. A transfer of unspent FY 1978 capital equipment funds of $767,000 is reduced to 0 because of the rescission.

## PROJECTS TO BE FUNDED IN FY 1982

The following table presents a listing of projects to be funded in FY 1982 in the Energy Storage and Electric Energy Systems Programs:

Energy Storage ($38.5*)

- Thermal Energy Storage ($4.0 million)
  - Research and development on sensible and phase change materials, and components for heating and cooling in buildings ($1.6 million)
  - Testing of heat exchangers components for application to district heating ($1.4 million)
  - Modeling and experimentation on thermocline storage systems using sensible heat ($0.35 million)
  - Research and development on heat transfer and transport methods ($0.65 million)
- Chemical/Hydrogen Energy Storage (CHP) ($1.15 million)
  - Development of a rapid cycling metal hydride heat driven CHP for cooling in small and large buildings ($0.5 million)
  - Development of a CHP for generating high quality heat (+300°F) ($0.5 million)
  - Cost study of CHP systems ($0.15 million)
- Mechanical/Flywheel Energy Storage ($1.7 million)
  - Development of improved composite materials for flywheel rotors ($1.3 million)
  - Continuation of testing and characterizing flywheel rotors ($0.4 million)
  - Exploratory development of bearings, seals, and containment structures ($0.4 million)

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*Does not include Program Direction

Underground Energy Storage ($4.1 million)

- Compressed Air Energy Storage ($1.9 million)
    - -- Field experiments on aquifers at Pittsfield, Illinois site ($1.4 million)
    - -- Laboratory experiments for characterization of aquifer materials ($0.3 million)
    - -- Analytical modeling of aquifer performance ($0.2 million)
- Seasonal Thermal Energy Storage ($2.2 million)
    - -- Field experiments with hot water injection/recovery - two sites Auburn University, University of Minnesota ($1.1 million)
    - -- Economic, Technical, Institutional, Environmental Assessments ($0.3 million)
    - -- Comparative studies of field and lab experiments, modeling results ($0.3 million)
    - -- Non-aquifer storage studies as applied to areas where aquifers may not be suitable ($0.5 million)

o Superconducting Magnetic Energy Storage ($0.9 million)

- Completion of a small scale (10kWh) storage device for transmission line for stabilization installation and testing on the Bonneville Power Administration systems; the device is about one-half completed at this time.

o Electrochemical Technology Base Research ($10 million)

- Supporting research ($4.5 million)
- Electrochemical systems research ($4.0 million)
- Electrolytic processes research ($1.5 million)

o Electrochemical Exploratory Technology Development ($12.7 million)

- Non-aqueous electrochemical systems ($7.1 million)
- Aqueous electrochemical systems ($5.6 million)

- o Electrochemical Applications Research ($2.85 million)
    - Mobile applications ($1.5 million)
    - Batteries for specific solar applications ($1.35 million)
- o Capital Equipment ($1.1 million)
    - Electrochemical capital equipment ($0.7 million)
    - Thermal, underground, and mechanical capital equipment ($0.4 million)

Electric Energy Systems ($9.0 million*)

- o Power Delivery ($4.9 million)
    - Selected biological studies on electric field effects on animals ($1.0 million)
    - Generic high-voltage direct current research ($1.9 million)
    - Advanced insulating materials developed from fundamental dielectric studies ($1.0 million)
    - Research on key high-voltage alternating current options ($1.0 million)
- o System Architecture and Integration ($4.1 million)
    - Advanced concepts for the integration of dispersed sources ($2.1 million)
    - Control and reliability methodology for handling normal and emergency system conditions ($2.0 million)

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*Does not include Program Direction

## REDUCTIONS IN THE FY 1982 PROGRAM

In the Energy Storage Program there are reductions in all planned subprogram activities for FY 1982. The Thermal Energy Storage Subprogram demonstrations of thermal storage for waste heat conservation in industrial processes will be deleted. Thermal energy storage demonstrations for district heating in Bellingham and the first advanced district system utilizing industrial waste heat will be abandoned. The planned solicitations with HUD for additional demonstrations will be cancelled, as will demonstrations of the use of off-peak electric for home heating and cooling.

In the Chemical/Hydrogen Energy Storage Subprogram, DOE participation in the IEA Hydrogen Production Agreement may be cancelled due to elimination of projects. Storage, distribution, and use activities for FY 1982 will also be deleted. In the Mechanical/Flywheel Energy Storage Subprogram, design, upgrading, and development of prototype and testing systems will be deleted. In the Underground Energy Storage Subprogram, underground pumped hydro research, adiabatic compressed air energy storage (CAES) development, and seasonal energy storage aquifer demonstrations will be deleted. In the Mechanical Applications Subprogram, the on-going design and cost study for use of compressed air storage will be phased out. All transfer of technology work and licensing assistance will be terminated.

In the Superconducting Magnetic Energy Storage Subprogram (SMES), the development of technology for large scale high efficiency utility SMES will be deleted, as will cost and technical evaluations of improved design concepts and cofunding by Electric Energy Systems. In the Technical and Economic Analysis Subprogram, assessment and evaluation of storage R&D requirements and energy storage potential for solar, industrial, and district heating and cooling will be deleted, along with preparation of an energy storage bibliography and updating of a computerized technical information system.

For the Electrochemical Energy Storage Subprogram, in the technology base area there are reduced levels of effort on aluminum/air cells, ambient temperature lithium cells, fuel cells for transportation, materials, components, and electrochemical phenomena related to performance. In the exploratory technology development area there are reduced levels on flow battery systems and in the high temperature non-aqueous battery systems. In the mobile application area the supporting research on near-term electric vehicle batteries is eliminated. In the dispersed battery application area the Battery Electric Energy Storage Facility and the Storage Battery Electric Energy Demonstration Project are terminated. In the batteries for specific solar applications area, research on batteries for photovoltaics and wind applications, hardware testing, and field experiments is eliminated.

In the Electric Energy Systems Program, major projects have been eliminated in the FY 1982 budget revisions. These include advanced systems concept work for optimizing and controlling future complex electric networks, development of automated system analyses, generic electric field effects research, alternative underground transmission options, high voltage transformer and DC switching research, feasibility tests and benefits assessment of storage battery load leveling on utilities, and development of modeling and planning concepts for dispersed and central generations and storage. In addition, projects will be eliminated in the areas of electric field effects on animals, 1200 kV key compact station research, ZnCl advanced battery lab prototypes, modeling of advanced underground transmission cable options, advanced superconducting generator research at MIT, long-term health risks from high voltage electric fields, TVA/Athens utility distribution system automation, advanced planning of dispersed generation distribution systems, operating strategies for new system/source interfaces, and design options for low-loss amorphous metals in transformers, rotors, and generators.

Mr. **Forsythe**. The small-scale hydro, I have some small interest in this. Do I understand you have actually closed out on applications, and I mean the real small ones?

Ms. **Savitz**. We have funded about 150 of those applications. We have received over 300. We have not funded any more than the 150, and I don't think we will.

Mr. **Forsythe**. Do you have a bottom line on that number?

Ms. **Savitz**. That is $5.8 million. Oh, the size you mean?

Mr. **Forsythe**. I suspect it would come in under the 10-foot level?

Mr. **Furse**. No; I think the small cutoff, that you may be referring to is the 100 kilowatt threshold that we are using. We have not been making loans for projects below 100 kilowatts. That cutoff was an arbitrary decision when the program was just getting started. It only became operational in April, as was said earlier, and we have found since that there are projects below 100 kilowatts that would be economically feasible, but they are progressively less economic the smaller they get.

Mr. **Forsythe**. You refer to it on page 7. Another research activity involves 12 conceptual studies and one field test for ultra lowhead applications, less than 10 feet.

Do we have a list of those studies?

Mr. **Furse**. Yes; I misunderstood, yes, we can get that list for you.

[The information follows:]

## Projects Selected for Ultra Low-Head R&D

| Proposer | Proposal Title |
|---|---|
| Aerovironment Inc.<br>145 Vista Ave.<br>Pasadena, CA 91107 | Definition of Cost Effective River Turbine Designs |
| Allis-Chalmers Corp.<br>P.O. Box 712<br>York, PA 17404 | Powerhouse - Gate |
| Arizona State Univ.<br>Tempe, AZ 85281 | The Hydraulic Air Compressor as part of an Ultra Low-Head Hydropower System |
| Arthur D. Little, Jr.<br>Acorn Park<br>Cambridge, MA 02140 | Demonstration of Scroll Motor Advantages for Ultra Low-Head Hydroelectric Power Generation |
| Energy Research and Applications, Inc.<br>1301 El Segundo Blvd.<br>El Segundo, CA 90245 | Design of Low-Cost, Ultra Low-Head Hydropower Package Based on Marine Thrusters |
| Gilbert Associates, Inc.<br>525 Lancaster Ave.<br>Reading, PA 19602 | Modular Hydro Dam |
| Lakeside Engineering<br>Mirror Lake, NH 03852 | Modular Innovations in Upstream Fish Passage |
| New Found Power Co.<br>Box 576<br>Hope Valle, RI 02832 | Ultra Low-Head Cross-Flow Turbine Exploratory Development |
| Science Applications, Inc.<br>No. 5 Palo Alto Square<br>Suite 200<br>Palo Alto, CA 94304 | Kit for Unattended Adaptation of Low-Head Dams to Electricity Production |
| University of Missouri-Columbia<br>Columbia, MO 65211 | Use of Head Augmentation Devices in Ultra Low-Head Hydropower--A Feasibility Study |
| Virginia Polytechnic Institute and State University<br>Blacksburg, VA 24061 | Optimization of a Diffuser/Ejector for Ultra Low-Head |
| Turbomachines, Inc., and The James Leffel & Co.<br>Springfield, Ohio | Develop Vertical Cross-Flow Design |

### Field Test

| | |
|---|---|
| Turlock Irrigation District<br>Turlock, CA | Demonstrate the Schneider Lift Translator and Engine at Drop #6 |

Mr. FORSYTHE. At times it is awfully hard to not just try to push for more, I realize. Do you feel comfortable that you at least are expending your dollars in the most productive areas, and that we will be able to get us the most bang for the buck in terms of continuing this program at this level?

Ms. SAVITZ. Yes; we have over the past year instituted a system where we can make tradeoffs on cost/benefit analysis, have some sort of rigorous criteria for which projects we can select and only fund those that have the best potential savings in energy savings or energy displacement of one fuel or another.

Mr. FORSYTHE. OK. Thank you.

Thank you, Mr. Chairman.

Mr. WOLPE. The gentleman from New Mexico.

Mr. LUJAN. Dr. Savitz, in your statement you say that the low-head hydropower program has been reestablished. Will the United States reawaken interest?

It seems, at least I gather from the statement, that all of the technology in turbines and all of those things are ready to move on ahead. Is that what you meant, that it is feasible and can be built now; then why is DOE involved in research, if they are?

Ms. SAVITZ. Yes; and also there are incentives that will have the private sector invest in the small hydro so that we will implement it. The technology is there and then there are also other incentives like Federal Government tax credits.

Mr. LUJAN. That wouldn't go into your budget, would it?

Ms. SAVITZ. No.

Mr. LUJAN. Yet you are doing some work in research and development, maybe demonstrations in low-head hydro?

Ms. SAVITZ. Some are currently underway and Dr. Furse can speak to them if you want.

Mr. LUJAN. But none in 1982?

Ms. SAVITZ. No.

Mr. LUJAN. You are transferring those over to private industry because they are ready to go and you have got other incentives to——

Ms. SAVITZ. Pick them up.

Mr. LUJAN. On the batteries, did you say we already have one battery that will go 70 miles one one charge?

Ms. SAVITZ. The advanced lead acid battery that we had been developing jointly with Globe Union is now a commercial product, and that can go 70 miles until you have to recharge it. Also the life of it is longer and many of the electric vehicles that we are purchasing this year under the Demonstration Act will include those batteries.

Mr. LUJAN. Did I understand you can keep recharging it?

Ms. SAVITZ. You can keep recharging it. I will give you the exact number: it will supposedly go almost 50,000 miles as compared to the commercial lead acid battery which would go 13,000 miles before you need to replace it. So the cycle life of it has increased very dramatically, and it is a very good accomplishment of this program.

It was done jointly with industry. We changed the direction of some of the grids to increase the life. Instead of their being vertical they made them slanted; and that helped improve it, and they are now producing those.

Mr. **Lujan**. On electrical energy storage, Los Alamos and Bonneville were working on a low temperature magnetic electric storage ring. Is that the one that you are referring to? Has the engineering and ordering of parts and those sorts of things have already occurred?

Ms. **Savitz**. Right.

Mr. **Lujan**. Will we continue funding that to construction and testing? Where is that now?

Mr. **Brogan**. The current plans for fiscal year 1982 include assembling the components and testing them at Los Alamos.

Mr. **Lujan**. And probably install it in 1982? Would Bonneville be paying for it if it tests out well? Would you just move it on to Bonneville?

Mr. **Brogan**. Discussions with Bonneville take place this year, concerning whether to transfer it and install it at Bonneville.

Mr. **Lujan**. Is Bonneville contributing to it?

Mr. **Brogan**. No, not at present.

Mr. **Lujan**. What about EPRI? We also hear about all of the research that they do. You monitor that pretty carefully and when they are willing to take something that looks promising, DOE steps back. What are they doing there?

Ms. **Savitz**. We work very closely with EPRI and many of the projects have been jointly funded with EPRI that range across the board in both the electric energy systems and the energy storage programs.

A couple of examples are things like the zinc chlorine battery. A third of the money was ours and in the development, the building of this Best facility has been a 50–50 cost-sharing with us and with EPRI.

What we are currently doing is having conversations with EPRI as our program is changing direction and focus, EPRI might do some of the more near-term things if industry is not going to pick them up.

Mr. **Lujan**. You get some pretty good vibes from them, so to speak?

Ms. **Savitz**. It is a very good relationship. The utility industry has problems in its finances, the amount of money that EPRI gets is decreasing slightly, but their efforts in conservation and energy efficiency have really been increasing over the past 2 years, and it has been a very, very good effort across the board in these programs.

We have the same goals and aims and work well together.

Mr. **Lujan**. One final question: Assuming that we did not do all this research, the electrical energy storage, battery, all of the research, and that other countries did move forward, why couldn't we just buy it from them and save a lot of money?

Ms. **Savitz**. We can buy it, and we are doing that in other technologies.

It depends what type of American industry and technology one wants to have. I think we would like to see the United States be a leader in technology development, as it has been through the last decades, and one of the best exports has been high technology and technology development and then also the products that come as a result of that.

It is hoped that with the incentives that the administration is proposing that we will spur on investments both in equipment and also in research and development that we will maintain our leadership role, and so this can happen.

Mr. LUJAN. Are there tax incentives for research and development or just for purchasing equipment?

Ms. SAVITZ. Well, there currently are some tax incentives. You can expense it off for research and development for the equipment that you have to purchase.

I just do not know the details of the tax proposal, but whether that will include writeoffs of the equipment that you buy for R. & D. in a faster way too would also help.

Mr. LUJAN. It probably does, write off on the R. & D. and 5-year writeoff on the equipment.

Ms. SAVITZ. That would then help to spur on the country.

Mr. LUJAN. Thank you very much, Mr. Chairman.

Mr. WOLPE. I would like to pursue the small scale hydropower area for just a moment. What is our estimated potential of small scale hydropower to contribute to the supply of electric energy in this country?

Mr. FURSE. We have been working with the Corps of Engineers to try to define reasonable assessment of small-scale hydro. It is not an exact science, because it is something like counting the blades of grass on our lawn. The smaller you go, you magnify the number of projects tremendously. In the early corps assessment, they had listed several thousand sites at existing dams and about 3,000 new sites.

Their latest assessment which they are finalizing this year will trim this down quite a bit, and we probably will show about 1,100 prime existing dams that could be retrofitted in say less than 30 megawatt size, but we don't have a good cutoff point at the lower end. In some States they cut it off at 5 megawatts. In some cases they cut it off at 1 megawatt, and we, for example, in the loan program, have been going down as small as 100 kilowatts, so there are a lot of the smaller dams that are not included. They also show about 300 to 400 new sites where dams could be built. All of these will total about 15,000 megawatts of capacity that could be added; and if you add that on top of the 63 thousand megawatts of hydro power capacity that we have, that would be adding on about one-fourth again the installed capacity from sites of the small size.

Mr. WOLPE. If our total energy consumption, do you have a guesstimate at least as to the potential contribution of hydropower?

Mr. FURSE. The present contribution, small and large, is about 12 to 13 percent, and so we are talking about a capacity that could be added on top of that of about one-fourth of the present installed capacity.

Mr. WOLPE. Somewhere between 16 and 17 percent would be the total. Do you expect this potential to be fully realized without further governmental assistance?

Mr. **Furse**. It is a little early to tell because, as Dr. Savitz said, our objective has been to reawaken the interest in small hydro, the technology, as they have said, is mature.

Now, we are discovering right now and over the past months, a tremendous growth in this interest. So people from the private and public sectors, non-Federal sectors are very interested, but we are really at an early stage and it is subject to some projection.

Mr. **Wolpe**. Do we have any hard evidence that industry will provide the capital investment or local or State governments will provide the leadership necessary to fully develop those resources?

Mr. **Furse**. Some States are taking a very aggressive role. New York, for example, and California. New Hampshire has set a very lucrative rate for the power to be purcahsed under the PURPA requirements.

As for industry, again it is a little early. We have learned from talking with people that are entrepreneurs, bankers, that there is a lot of interest; but, again, we are at the beginning of the growth period, so we can't really point to projects that have been built, of course.

Mr. **Wolpe**. I would like to swtich now to the general question of electricity storage. In particular, in one of the major, as I understand, one of the major long-range objectives would be to enhance load leveling on our utility operations, so that essentially the need for constant construction of new powerplants to address the peak demands which occur at very occasional times of the year become less paramount. You simply don't have to engage in that kind of additional construction.

What is the state of the technology as relates to the kinds of energy storage that would facilitate that kind of load leveling and give us some kind of reasonably graphic illustrations as to the state of the research.

Ms. **Savitz**. I will give one example and ask Ken Klein to give a couple of others. We have been developing batteries that would help for the load leveling. One of the ones has been this lead acid battery technology that we talked about.

It is estimated that if you install those for a 50-megawatt peaking for a powerplant operated at 2,000 hours a year, you could save over $7 million a year in energy when you are not running your oil-generating capacity, and the batteries might cost $6 million or so, so it is a very good payback.

Again, this technology is something that is just coming on the market. The zinc chloride system that was announced last May by Gulf & Western and us and EPRI was initially started out to be a battery for utility load leveling, and that work is still continuing. It has still some more technology development before it will be ready for full application, but it has potential for being a cheaper system with longer life.

Mr. **Klein**. The question you ask is a complex one. Storage is just one technique for reshaping the load curve. It isn't necessarily true that storage will always change the amount of new construction that will have to take place. It is probably true, though, that it will be a good displacement of the peaking oil that is used during peaking times.

A whole combination of things go into this reshaping process. You fall away from customer storage of heating and cooling techniques to battery storage on the electrical system, compressed air system, on the electrical system which would be much larger in capacity, the large pumped hydro storage.

You could also talk about loading management from the point of view of controlling loads and automating the distribution system so that you can effectively do this kind of work, and it is all a package, and it all is competitive with each other and is very site-specific.

A generalized answer to the question is very difficult, therefore, and you really have to think about these things as a package and what happens on a system. That is the reason the system work is so important to evaluate these from a non-advocacy or a neutral point of view.

Mr. Wolpe. Describe what technology for energy storage is needed for use of solar energy and give an estimate of when that technology will be needed for this purpose?

Mr. Brogan. Many of the same technologies that we are developing for load leveling are also applicable to storing solar energy and to other intermittent energy sources, such as wind energy.

The advantage of energy storage is that it would permit the intermittent sources to behave as if they were continuous sources of energy; that is, if you store the energy during the times when the Sun is shining (or the wind is blowing), the stored energy can be used during nights or cloudy days (or when the wind is not blowing).

Most of the storage activities that are aimed at solar applications are jointly supported by the solar program within the Department, especially thermal storage and battery storage.

Battery storage is the most convenient form of energy storage for the solar program. The zinc bromine and redox batteries are two of the electrochemical systems that have been under development and will continue to be developed in the current funding plans.

Small units of a couple of kilowatts size have been tested, and they will be scaled up to larger size with the fiscal 1982 budget.

Mr. Wolpe. That is solar energy for electricity essentially that you are referring to now?

What about solar energy in terms of building materials? What is the state of the technology with respect to the development of materials that can store the energy, really store the heat?

Mr. Brogan. There will be a subsequent presentation by an industrial member of the team that is developing chemical heat pump technologies. In addition, the major developments for heat storage involve new phase change materials.

Examples of desirable phase-change materials that have characteristics, of predictability and ability to tamper with the fusion point are the glauber's salts, for low temperatures (heating/cooling uses) and nitrate salts for high temperatures (thermal power uses).

One problem with phase-change materials is that, they change their composition with time as they are used. The fusion point of the salt mixtures may change because we have not yet learned to make them in a way that will remain homogenous over a long time as they are alternately melted and refrozen.

Some subscale tests that have been conducted in laboratories and experimental homes where heat from off-peak electricity or from solar collectors has been stored in these materials. The current state of the art is that the program requires extensive research most phase-change materials are still too unpredictable, to be applied with confidence, for example, by the average homeowner.

Mr. **Wolpe**. How would the budgetary proposals that the Department is advancing now impact upon that element of the research effort in which the Department has been involved?

Mr. **Brogan**. It turns out very little impact in that program. We have selected the programs that would be significantly decreased by a rescission, and that is not one of them.

Mr. **Wolpe**. Would you describe the areas which would be most sharply impacted in terms of the research and development effort that is underway?

I would like you to put some meat on those programs so we can visually see as well as understand.

Ms. **Savitz**. In the storage area, in what we call the technology base and supporting research, they are really not affected at all. This is where we are looking at nonaqueous electrolytes, exploratory research on single electrode for recharging of single electrode chemistry of these materials.

They will not be affected. The work on some of the longer term where we looked at cells and aluminum area won't be affected.

As we get into the more applied area, the applications research particularly, this is where there will be over an 80-percent reduction, both with regard to 1981 and 1982.

We will be delaying some of the purchasing of the zinc-chlorine batteries for the testing at the Best facility, work on the storage battery electric demonstration project with the utility in Wolverine, Mich., to show a whole system affected when you get enough load-levelling batteries there to really collect data on a utility system as opposed to just the battery itself.

That activity will be terminated.

Mr. **Wolpe**. Do we have any evidence that the zinc chlorine work or that this storage battery work at Wolverine will be continued or is what we are saying here we are simply making a judgment that this is no longer valuable enough to continue in the program?

Ms. **Savitz**. The zinc chlorine work had been cost shared with EPRI and Gulf & Western.

We will under the transportation program do some more work for that for the Mobile applications. That will continue. For stationary applications, it is just not sure. In our discussions with EPRI this month and next month, we will be seeing, particularly for batteries that might be tested at the Best facility, which ones they might be able to pay more for, or it will take a longer time to get all the batteries delivered or just test less of them.

The experiment in Michigan would probably not go forward. It was involving a utility, and also then the technology to try it on their system and collect the data.

Mr. **Klein**. It is not a case that the project in Michigan is not a good project; it is just that levels of target funding that we had coming back, that the priorities are such that that is just not possible.

It is a good project. Other projects which would also fall into that category are some of the superconducting programs, the superconnecting cable at Brookhaven, and some of the electric field effects work that is going on would also be reduced quite measurably.

The distribution automation control and load management test bed in Athens, Tenn., would also be affected. The work on submarine cable, reduced work on the high voltage direct current activities, as well as some of the high voltage alternating activities, all of these would be affected.

Mr. **Wolpe**. This whole range of activities relate, do they not, to long-range research and development that is not of the sort that industry would be likely to pick up at this stage; is that correct?

Ms. **Savitz**. Well, industry, as I said earlier, is cost sharing it, and so they may continue with their part of it and it will stretch out the time for when it would have occurred. We will monitor, and also we are——

Mr. **Wolpe**. You are not talking about commercialization, near-term commercialization efforts here? You are talking about, rather, basic kinds of research and development, are you not?

Ms. **Savitz**. In some of these areas we are moving from the basic into the more technological areas, so that you need to build the first of the kind and test it out before you commit to production.

Mr. **Wolpe**. How would you characterize the level of risk involved in that effort?

Mr. **Klein**.. The whole range of programs that we have in the electrical energy system has a variety of risks. The superconducting cable, superconducting generating work, the work on distribution automation control has a level of risk that the utility industry, with its financial condition today, are very hesitant to move forward on without some further work, but it varies all the way from very high risk projects where the chances are unlikely to lower risk which we may have some considerable success.

Mr. **Wolpe**. It seems to me we ought to be asking ourselves to what extent are the proposed cuts cost-effective?

Are we in effect making decisions now that will mean higher cost, because they will mean our continued dependence upon high rates of energy consumption over a long period of time?

Is it possible to provide, if you were to prioritize the kinds of research efforts the Department has been into over the years, what is the potential for the work that is being done in the storage area as distinct from the work that is being done in other alternative energy technologies?

How much, what is being sacrificed?

Ms. **Savitz**. The thing is, the storage area particularly is really a supporting technology that enables a lot of the technology developments that are going on in the other renewables and in the conservation areas to be successful.

For example, with the solar type program, by having adequate storage, you can extend the time or reduce the time that you need actual sunlight, so that you help make those systems cost-effective.

In order to get a viable electric vehicle system, we are going to need good batteries, so that the two, the storage program particularly is a partnership program with all the renewables and the end use areas to extend both the reliability, the life, and also in some cases be able to reduce the cost, because if you can store this energy for longer periods of time, you may be able to have a smaller set of collectors.

It is hard to answer the question, because it is sort of a package type of arrangement. The storage related to utilities will be able to remove the less efficient peak generating capacity that is typically sufficient, and also is oil burning, so there you are making a direct substitution for a nonsort of a chemical, technology for an actual oil technology, and so that becomes very important for meeting the demands of the utility in using nonpetroleum products.

Mr. KLEIN. The electric system is also an extrapolation of that fund. Without the appropriate controls available, looking at storage and the renewable resources as a new kind of function in an electric system, the future system as it becomes more complex with those new dispersed and intermittent technologies, really will not work without new control systems, without new communication means and all the rest that goes with it.

Mr. WOLPE. You were taking off the areas of greatest impact in the proposed budget. Any other specific areas that would really kind of jump out in terms of a reduction of effort?

Ms. SAVITZ. In some of the specific storage areas, other than the electrochemical ones, some of the chemical hydrogen storage areas, and that is the area of the hydrogen production which will be deleted in fiscal year 1982, and the mechanical flywheel storage program basically will have a 50-percent reduction.

We will continue work on composite material for flywheel rotors and testing and characterization of these. Certain things, such as the design of a 10-kilowatt hour fixed base flywheel for a specific application, will not be continued in that year.

In the underground energy storage system, there are the areas where we have been which were ready for demonstration and will not be continued, particularly, the aquifer system where we have been drilling for water and then will take the waste heat from a powerplant, store it there in the summertime and in the wintertime be able to extract the warm water, use that to heat hospitals or schools.

We have been doing some site demonstrations in Alaska, Minnesota, and New York. We will not go forward with the demonstration. It is hoped that perhaps the university or hospital will.

Mr. WOLPE. Earlier you referred to the superconducting cable project at Brookhaven National Laboratory. What is the status of that project and how much has been spent on this facility so far?

Ms. SAVITZ. OK; the 100-megawatt, we have all the materials together, ready to actually demonstrate or pull that system together, and that program will not be continued next year.

Mr. KLEIN. The test site is completed. The cryostat and the refrigerator are all in place. The cable itself is being fabricated and would be still installed this year, but the long-range testing of that cable and further research would have to be terminated.

Ms. SAVITZ. We have spent about $20 million since 1972 in that project.

Mr. WOLPE. And how much had you planned to spend this year originally?

Mr. KLEIN. $2½ million.

Mr. **Wolpe**. We don't have any results yet from that project? Is that investment then just being discarded, the $20 million?

Ms. **Savitz**. As I said, it is being assembled this year, as Ken said, and it is being installed in the test facility and it is anticipated that the private sector will pick up the activity.

Mr. **Wolpe**. When you say anticipated, do you know that for a fact? What if they say no? Will it just sit there presumably?

Ms. **Savitz**. If they say no, we will have to reassess it and discuss within the administration what the effects of that are.

Mr. **Wolpe**. With what funds?

Mr. **Klein**. We have no specific information that the private sector would or would not do this.

Mr. **Wolpe**. Are there other facilities where we have a substantial research investment that are being terminated essentially in mid-stream after a rather substantial investment has been made?

Ms. **Savitz**. One of the ones is in Best facility, which is this battery engineering test facility.

Mr. **Wolpe**. In New Jersey?

Ms. **Savitz**. Yes; in New Jersey. That is fully filled and we have bought or are installing the lead acid batteries which will be used as sort of the standard battery for testing new batteries against.

What we will not be able to do is purchase advanced batteries to test in the facility. That is one of the things we are discussing with EPRI, whether they would be able to put more money into purchasing some of those batteries. The facilities will also be available for the private sector to use on their own.

Mr. **Klein**. The electric energy systems program does not have a great deal of facility as such. That is usually the cost-shared part of our contract, that facilities are built by the private sector, but there are a number of areas where we have embedded research costs that are quite considerable that will not be continued.

Mr. **Wolpe**. I have been going on for some time here and I don't want to monopolize.

Mr. **Lujan**. On that, I suppose if I were trying to develop a battery I would give you the battery to test it out and see if it worked out. Is that kind of the plan?

Ms. **Savitz**. The plan is that they would be able to go to that facility and put their manpower on it and put their batteries and test it out.

Mr. **Lujan**. The fact that you are closing down the program, not buying any new batteries, shouldn't hamper the testing of batteries?

Mr. **Klein**. So long as that battery is able to be produced by the private sector, that is right, with their funds. There are no batteries presently ready; they are still in the research stage.

Mr. **Lujan**. I had one question: For years and years we have heard about production of mill electricity through tidal waves, that sort of thing. Is anything going on there any more?

Mr. **Klein**. Probably the most amount of work is going on in Europe. I think we have found that the investment is much higher than the end product with present technology, and I believe that several years back, like 3 or 4 years ago, the Department decided that that was not a high enough priority to continue.

The Canadians have a great interest, in the Bay of Fundy, also, as you may recall, but it is very spasmodic.

Mr. LUJAN. We are always reading about just improving turbines. I don't know to what percentage, but that would save in the area of 6 million barrels per day, just making them a little more efficient. Anything going on along those lines, present generating equipment, making it a little better?

Mr. FURSE. I don't have the data at my fingertips but, yes, you are right. I understand that the Corps of Engineers and our own Idaho operation staff have looked at that and decided that if a very small fraction of improvement could be made, and they thought that it could, we could gain quite a bit, and if you would like, we could find out exactly what is going on.

I do know that they are looking at that.

Mr. LUJAN. It seems like a natural.

Ms. SAVITZ. The other thing is trying to recover the heat that is produced in excess, the use of that has a lot of potential. There has been a lot of incentives to do new heat recovery techniques.

Mr. KLEIN. You are also talking to the heart of the superconducting generating program because we are trying to get rid of the losses in the generator as it generates electricity. To improve the efficiency by a few tenths of a percent was enough to pay for the investment cost of that new generator in the utility installation, so essentially after the payoff period was over the machine would be totally depreciated.

Within like 5 to 7 years they would get back their investment, so there is a benefit there and loss reduction of virtually all parts of the electrical system.

Mr. LUJAN. That does not come under your area?

Mr. KLEIN. We have the superconnecting generator in our area, yes, the advanced generator concepts, but——

Mr. LUJAN. That is continuing?

Mr. KLEIN. No; it is not.

Mr. WOLPE. What is the cost of phasing out the project at MIT on superconducting generators?

Mr. KLEIN. The best estimate we have at this moment is that the cost of phasing out that program is about equal to the cost of the proposed budget for 1982, about $2½ million.

Mr. WOLPE. In other words, the total budget allocation will be used to simply phase out the project?

Mr. KLEIN. We would have to do that, yes.

Mr. WOLPE. How much has been expended on the project up to this point?

Mr. KLEIN. I believe about $5 million, possibly $7 million.

Mr. WOLPE. I call upon the gentleman from Missouri.

Mr. VOLKMER. Thank you, Mr. Chairman.

I would like to continue on with the New Jersey battery storage test facility.

The budget you propose, would the facility be able to continue to maintain its personnel that are presently there through 1982?

Mr. KLEIN. The personnel that are there are personnel from the Public Service Electric & Gas Co. That facility, the building is owned by a public service electric gas company, and presumably during the period of mothballing they would reassign their personnel to some other function.

Mr. VOLKMER. In the event of whether it is Union Carbide or anybody else who came up with a new type of battery that they would like to have tested there, they wouldn't be able to do so 6 months or a year from now?

Ms. SAVITZ. The facility will still be there; they would have to get personnel.

Mr. VOLKMER. Buy them all back; the chances of that, in my opinion, are very remote.

Ms. SAVITZ. Often these people get reassigned to other responsibilities. EPRI is concerned also about the Best facility, and they are looking at their budget to see whether they would have any funds for minimum maintenance people there.

Mr. VOLKMER. On the small hydropower low-head program which I see is being phased out, and I have reservations about that simply because I see other things happening, especially on public dams, I see the possibility that we are just going to chop it off all together.

To give you an example, and we will find out within another few months whether I am right or not, but I have a district that has six lock and dams on the Mississippi, and we have been working with the Corps on getting the applications for various utilities as to putting those low-head hydro plants in there.

It looks like they are going to be shut down on money. We are shutting down on demonstration on this end. I am afraid we are just going to see a total shutdown.

Ms. SAVITZ. You don't feel your district or some private investor will come and pick it up?

Mr. VOLKMER. No; I don't believe so. I don't believe Union Electric or Royal Electric, either one, which are the two along there over in Illinois, right across the river in Illinois, Illinois Power, any of them; no question in my mind they are not going to do it. They are too involved right now on either nuclear power or coal plants, and they are not going to come up with that additional money to do it without somebody pushing them.

Ms. SAVITZ. The regulating body, the PUC's won't they encourage them to do it with the cost and lack of risk involved?

Mr. VOLKMER. Look at it this way: When you have a project coming on that will provide all the electrical needs of the total area without this, where is the incentive to do it?

Ms. SAVITZ. Partly it's the costs, I mean the huge capital investment.

Mr. VOLKMER. You have already put your money in either nuclear or coal, and it is already invested and it will produce the electrical energy you are going to need for the next few years, so what's the use of going ahead in that? There is none. They will continue to put it in nuclear or something else, so we will continue to see it sitting there.

That is an observation.

The other observation, I see these things happening, I see it in coal from our new Department of Energy, but I don't see it in nuclear. In nuclear I see continuation of demonstrations; let's open Barnwell, and go ahead with breeder reactor. Why don't we say there too, let's just let the private industry do it?

I am not asking you for that; you don't have to comment. That was just an observation.

That is basically all I have.

My feeling is what I see under the new programs proposed that we say basically, let the private enterprise do it; and if they don't do it, tough luck, and we will go away and see what happens.

Ms. **Savitz**. It is also to provide incentives to private industry to do it through the price, and then also through taxes which earn tax incentives which do not show up in the Department's budget, so there is very definitely a commitment that price will encourage the right type of investments, whereas price is being distorted in the past by much of it being controlled, some controlled or some not controlled and again allowing the energy tax credits to remain and then pushing the whole philosophy of general investment occuring in this country, not just in energy but across the board by accelerating depreciation and the writeoffs and to make this so that will help so there is a substitute for one type of support for another.

It would be one way of putting it.

Mr. **Volkmer**. I hope it would.

Ms. **Savitz**. We all hope it will.

Mr. **Wolpe**. I want to go back for a moment to the Wolverine project.

What is the status of the project?

Mr. **Klein**. The only remaining hurdle to be passed is a State attorney that is still looking at some of the economic analyses and asking some questions that the Public Utility Commission and the attorney general's office of the State need answering.

Other than that, a letter of agreement has been signed; the contract is ready for implementation, once that hurdle is removed.

Mr. **Wolpe**. How would the budget proposals this year impact upon that project?

Ms. **Savitz**. We would not go forward with the purchasing of the batteries for that project.

Mr. **Wolpe**. Do we have any assurances that that will be picked up by anyone?

Ms. **Savitz**. I don't know whether the manufacturers will go ahead and work with the utility to do it because it will give them a real test case of how their battery is doing in real operation, of a utility getting data, not just in isolation but as part of a whole system; and this could give them valuable information to then market it to other utilities.

If they see a market on that, particularly if utilities are going to look to further remove any oil generating capacity, they could proceed with it on their own, and we would work to give them technical assistance to help make that happen.

Mr. **Klein**. We have not had a chance timewise to really pursue that question.

Mr. **Wolpe**. Mr. Klein, something you mentioned earlier with respect to the research and development of both theory and technology for the operation of increasingly complicated electric systems in regard to interconnecting large systems and integrating diverse energy sources. Who will take up the slack when DOE drastically reduces this work in that field? Whose legitimate responsibility do you believe that kind of work really is?

Mr. KLEIN. Much of that work is very long range, and presumably the universities would be in the most logical position to look into that specific area. We also will obviously have to be in conversation with EPRI to find out if they are able to do funding in this area. There are some contacts with industry that we will have to pursue to see whether they in fact will or will not be able to follow through on it.

As you appreciate, the short leadtime so far since the budget has been announced we really have not had a chance to pursue that question indepth.

Mr. WOLPE. Are there some fairly fundamental questions here?

This relates, I take it, to integration to assure proper integration of solar and other sources?

Mr. KLEIN. There are a number of issues that are not well understood today. If you picture in your mind the fact that today's system is designed for central generating plants only, and there is really only one direction of energy flow from the generating plant out to the load.

We started adding the disbursed and often intermittent technologies throughout the system, the whole system concept of design, the way it is developed, controlled, the safety features of the system and the protection not only of the system itself, but also the equipment and the personnel involved have to have considerable work done on it to make sure when those devices do become available, that they will fit harmoniously in the system.

That is not possible with today's equipment.

Mr. WOLPE. Is it realistic to think that the utilities themselves will pick up without Government support?

Mr. KLEIN. It is realistic to believe they will change their system slowly to accommodate for small amounts of these devices as they come on the system, and they have always reacted in the past to those incremental changes and have reacted quite well.

It is unlikely that they will look at the big jump in the future system until they really have the equipment already on their systems, and they are faced with the operating problems connected with it.

Mr. WOLPE. You indicated the university would be the most logical institution where this kind of work should be conducted, but is not all Government funding for such university research being eliminated in the proposals before us?

Mr. KLEIN. Certainly a large percentage of the university money is being phased out.

Mr. WOLPE. Finally, let me just ask how much of the budget for electric energy systems in fiscal year 1981 and 1982 is directed toward long-range research, that is, research which would likely find application only after 5 years or more?

Ms. SAVITZ. About 70 percent long range.

Mr. WOLPE. And what percentage of that budget is being eliminated?

Ms. SAVITZ. In 1981 I guess it is just about 10 or 15 percent is being eliminated in 1982. From the original January 15 submission, about 70 percent.

Mr. WOLPE. Seventy percent.

Thank you.

I want to thank you all for your testimony this morning and for walking us through the proposed cutting of the programs that fall within the jurisdiction of the subcommittee.

Thank you very much.

Ms. SAVITZ. Thank you, Mr. Chairman.

Mr. WOLPE. I am pleased to welcome now Mr. William Thorn, director of energy research and development, Rocket Research Co., and Dr. Robert F. Lawrence, Westinghouse Electric Corp., from Pennsylvania.

We are very pleased that you gentlemen could be with us this morning to provide testimony with respect to the programs within the energy storage area that fall within the jurisdiction of this subcommittee, and also with respect to the electric energy system questions.

The full statements that you have submitted will be entered into the record at the beginning of your respective testimony, and I would ask if you would at this point summarize whatever additional remarks you would like to make.

Dr. Thorn?

## STATEMENT OF WILLIAM F. THORN, DIRECTOR OF ENERGY RESEARCH AND DEVELOPMENT, ROCKET RESEARCH CO.; DUANE LUNDAHL, EASTERN REGIONAL MANAGER, ROCKET RESEARCH CO.; ROBERT F. LAWRENCE, WESTINGHOUSE ELECTRIC CORP.

Mr. THORN. Mr. Chairman, members of the subcommittee, with me today is Mr. Duane Lundahl, manager of our eastern office here in Washington.

On behalf of Rocket Research Co., I appreciate the opportunity to address the subcommittee on the subject of Federal Government involvement in the energy research and development process. Since we have submitted written testimony, I will confine my remarks to a summary of the key points that we wish to make.

First, I would like to state that Rocket Research Co., endorses the administration's broad view that Federal spending should be reduced and that private development capital should be utilized wherever possible. Capital investment incentives in place now, and new or expanded incentives under consideration, can be very effective inducements in implementing this policy.

We expect that fuel price decontrol will also further the administration's aims by stimulating the development of new and advanced conservation technologies and alternative energy resources heretofore considered uneconomic. These developments collectively will reduce the demand for fossil fuels and foreign imports.

At the same time, it is important to note that selective Federal funding involvement in the development process can have a very beneficial impact on the time required to bring these new technologies and resources to the marketplace when this involvement reduces the real or perceived risks of the projects. In some cases, this involvement can determine entirely whether or not a new technology gets past the idea stage.

The ability to raise investment capital either internally or in the public market is highly dependent on the perceived or actual risk of the investor. Furthermore, the cost of publicly secured capital will vary in proportion to the risk.

While I do not presume to speak for all of U.S. industry, Rocket Research Co.'s work has provided an insight on investment attitudes within industry concerning energy-related projects. Typically, few or no risks will be taken with a new technology until it is shown that there will be no effect on production.

Given an acceptable production risk scenario, the project must compete with other, often production-related, capital investments on an economic basis. Here again, risk is a factor in that higher risk increases the project costs and adversely affects the overall system economics. In surveying public markets for energy-project investment capital, the risk factor is expressed somewhat differently but with a similar result.

High technology risks are not normally financed from public markets. Furthermore, the advice we get from such investors is that the energy source or fuel supply must be committed over a long term and the market for energy from the project must be secured with a long-term commitment. Some money markets even require all engineering and construction drawings to be complete before undertaking the project financing.

Incentives of the type previously described do not adequately reduce these types of risks and front-end costs at the critical time when the first decision to proceed with a project must be made. Often, a considerable sum of money must be spent in deciding to implement a project, and this is only recoverable through incentives if the project is found to be viable and proceeds to implementation. Similarly, few incentives are available to public agencies working to initiate such a project.

I would like to illustrate these points by reviewing briefly two Rocket Research Co. projects which involve Federal R. & D. dollars that are being used now or will be used in the future for risk reduction of the types I have noted.

The first of these projects is the development of a heat pump/chemical energy storage system. This is a high technology device that affords a potential for annual energy savings of approximately 35 million barrels of oil when fully utilized in industrial, commercial, and residential applications.

The system uses sulfuric acid and water as the working fluid. This media is alternately distilled with a reject or solar heat source to separate and concentrate its components, and then recombined to produce heat. Its process constitutes a thermodynamic cycle which provides a temperature amplification from inlet to outlet which is the heat pump principle of operation. If energy storage is desired for an application, supplemental tankage is provided to retain the separated working fluid components after distilling.

Development of this technology began several years ago. The viewfoil illustration is a 25,000 Btu/hr engineering test unit which reflects the system's current state of development. At present, under DOE sponsorship through Brookhaven National Laboratories, we are fabricating a 150,000 Btu/hr laboratory test unit, shown here, which incorporates energy storage and which will function in both a heat pump mode and a building heating/energy storage mode.

This unit is scheduled for testing this fiscal year. Requirement analyses in the present work have shown that industrial heat pumping is the nearest term application and that the range of sizes of interest to an industrial user extend upward from a 1 million Btu/hr rating or a scaleup of 40 to 1 from the present state of the art.

The technology factors and hardware scaleup required to achieve an industrial performance level have led us to propose such a design and industrial field test program to DOE for initiation in fiscal year 1982. Federal funding is vital to sustain the evolution of this important energy-saving technology since the cost attendant to the continued development of the industrial size units is significant.

Private funding for this activity is unavailable because there is no industrial operating experience that certifies the chemical heat pump performance predictions, economics, and equipment safety. Successful field testing will alleviate these risks and permit the initiation of a privately funded commercialization plan, which will in turn be greatly enhanced by present and planned incentive programs.

The estimated funding required for the proposed industrial development and field test is $660,000, and we are concerned that funding may be discontinued. If Federal funding is unavailable, there is a high probability that development will be terminated due to the risks I previously cited.

In summary, the chemical heat pump program illustrates how Federal involvement in a high technology project that has substantial long-range, energy-saving potential is acting to reduce the front-end risk that would otherwise preclude its development with purely private capital.

Continued Federal funding through the proposed industrial field test phase is urged to attenuate the remaining risk sufficiently to permit commercialization with private funds and to provide the opportunity for incentive programs to work.

The second project is the development of a district heating system in the city of Bellingham, Wash. District heating with hot water is not a new technology. The practice has been followed in European communities for many years.

What is new is its recent introduction into the United States where previous systems have evolved using steam which has a much more restricted distribution radius. With hot water designs, whole cities can now be heated instead of downtown business districts alone as per past practice.

The Bellingham project differs in several ways from most district heating systems developed previously in Europe or presently under consideration in several U.S. cities. First is the proposed use of reject industrial process heat as the energy source, and second is the service area selection wherein almost 80 percent of subscriber structures are single family residences.

Both of these characteristics are foreseen at many other candidate U.S. district heating sites. Two other unique, nontechnical features of this project are the absence of user equipment charges as an incentive to subscribe to the system, and an agreement by the city of Bellingham to repay DOE for portions of the current development costs when the full-scale system is implemented.

Finally, no DOE funding is planned beyond the current subscale field test phase. In the next phase, which is full-scale system implementation, local financing will be used.

These features combine to introduce an element of risk since the precedents are not well established in prior practice. The risk is perceived as greater than actual, partly because of the disparate entities involved, industrial, community, Federal, and commercial. Continued Federal funding support of this project through the present phase, therefore, is essential to project success to complete the risk mitigation process.

District heating is a technology whose hour has arrived in our country. It's energy-saving potential is immense. A few statistics will underscore the potential national impact of the technology represented by the Bellingham project. Approximately 40 percent of the total U.S. energy consumption is used in the industrial base and about 85 percent of this energy is rejected to the atmosphere at low temperature after use in processes.

Although no longer useful in the industrial plant, the rejected energy has sufficient utility to be used in community space and water heating. Not all industrial reject heat can be feasibly recovered. Taking only that fraction nationwide that is recoverable with present technology, it is estimated that 5 to 8 quads of energy can be displaced annually from the space and water heating demands of the United States using reject industrial heat.

Over 85 percent of this displaced energy is presently provided by oil and natural gas. This total displacement represents over 1,000 million barrels of oil per year, or approximately 10 percent of the country's total annual energy demand. Actual gas and oil displacement would be between 2 and 3 million barrels of oil per day, or over 25 percent of our Nation's oil imports.

The potential benefits of widespread implementation of this technology are clearly significant and highly desirable. The Bellingham project alone will displace oil, natural gas, and electrical usage equivalent to 200,000 barrels of oil annually.

The viewfoil illustration is a photograph of a semischematic model developed of the system. On the left is the Intalco aluminum plant from which the energy for the system will be derived. In the center is an 11-mile-long underground transmission pipeline which will carry the hot water into a heat storage and peaking or backup boiler plant located on public land at the Bellingham Airport on the edge of town.

From this site, an underground distribution pipe network will spread throughout the service area to individual users. Special emphasis has been placed on energy storage in this project to buffer the constant reject energy supply with the varying community energy demand. Storage evaluations have included both aquifers and an abandoned coal mine under Bellingham, in addition to the baseline concept of insulated, above-ground, steel tanks.

The next viewfoil shows the Intalco aluminum plant and its exoskeleton of air pollution control ducts which terminate in dry scrubber/baghouse equipment. The duct size is illustrated on the next viewfoil which also shows the planned location of the reject heat recovery heat exchangers in the horizontal section just ahead of the baghouse. There are 12 such sites in the full-scale system.

I might add, each of these ducts is about 12 feet in diameter.

The current phase is planned around risk aversion for the full-scale system. A small-scale district heating system will be installed within the eventual service area to provide an accurate assessment of the projected performance and installation costs and to serve as a community model to facilitate hookups in the full-scale system.

This small-scale area will later become an integral part of the full-scale system and will be partially repaid to DOE from full-scale system revenues. In parallel, one of the eventual 12 full-scale reject heat recovery heat exchangers will be designed and tested at the Intalco plant to confirm its compatability with plant systems and operations and to confirm its performance and costs. Further, selected engineering to support development of the full-scale system bond issue will be completed. These activities will extend into fiscal year 1984.

In carrying out this current work, the risks associated with the energy source, industrial plant interactions, system costs, and energy markets will be minimized, the bond issue will be well supported, and the requisite assurances will be provided to all parties, industrial, city, Federal, and bond counsel, to permit the completion of the system with locally arranged financing.

Interruption of the funding from DOE will stop the project due to lack of local funds to carry through this risk phase.

Considering the exceptional nationwide energy-saving potential of this technology and the need to encourage its widespread implementation, every effort is urged to assure continuity of funding through DOE as presently planned.

Once again, Mr. Chairman and subcommittee members, I appreciate the opportunity to address you with these thoughts.

Thank you for your attention.

I would be happy to answer any questions that you may have at this time.

[The prepared statement of Mr. Thorn follows:]

# ROCKET RESEARCH COMPANY INFORMATION PRESENTED TO THE U.S. HOUSE OF REPRESENTATIVES SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION

The decision-making policies concerning government spending for research and development should comprise three elements. First of all, the proposed R&D program should represent a technology which has a high potential for meeting national goals. Next, there should be a degree of risk or uncertainty associated with developing the new technology with the amount of government/private cost sharing in proportion to the degree of risk. Finally, the R&D program should be preplanned in phases so that the proper transition to commercialization by private or local interests can be achieved at a time when the benefits balance the risk. With this type of planning, new technologies can be rated to determine the level of government involvement. For example, if the proposed R&D effort involves application of a proven technology from a given industrial sector to a new process for another industry, the risk would be minimum and government support should not be involved. In this example, with current policies of accelerated equipment depreciation, tax credits and fuel price decontrol, successful commercialization can occur rather quickly. However, if the new technology involves unproven concepts or processes, then the risk and expense of commercializing is often so great that the idea is abandoned or the time to achieve full commercialization is longer than desired to meet the national goal or requirement. In this case, the government can assist the R&D effort to ensure that national goals can be met within the necessary timeframe.

To illustrate these points, two case studies of highly beneficial government participation in energy technology development and application are presented. In the first case, a product with high technology content and thus high technical risk is being developed. In the second case, the application of a technology proven in Europe is being pursued in a new U.S. social and regulatory setting with the added risk factor of utilizing an unproven but commonly available energy source.

## CHEMICAL HEAT PUMP/CHEMICAL ENERGY STORAGE SYSTEM R&D

Chemical heat pumps represent a new technology base with the ability to substantially reduce the consumption of energy in the industrial, commercial, and residential sectors. These devices provide an ability to recapture low-grade heat rejected from buildings and industrial sources and to reuse the heat at increased temperature levels for comfort and water heating or in a process. Chemical heat pumps operate with up to 15 times less electrical power and in higher temperature regimes, thus affording significant performance advantages over conventional heat pump designs. An additional advantage is that energy storage can be incorporated because of the working fluid selection so that intermittent energy sources, such as solar energy, can be utilized. It has been conservatively estimated that chemical heat pumps can eventually displace 0.2 quads (35.7 million barrels of crude oil) annually. The distribution of this energy is equally divided between utilization of reject industrial process heat and commercial/residential solar driven heating and cooling units. This reduction of crude oil consumption represents a reduction of foreign imported oil equalling 1.2 billion dollars per year (at $35/barrel*).

## PROGRAM STATUS

Rocket Research Company (RRC), a division of ROCKCOR, Inc., has been under contract for system development of the sulfuric acid chemical heat pump since 1976. Figure 1 summarizes the programs sponsored by the Department of Energy (DOE) totaling $1.3 million to date, including the current four-task Phase III contract being funded through Brookhaven National Laboratories (BNL). In the present effort, Tasks 1 and 2 are completed and consisted of a requirements analysis and a detailed design of a 150,000-Btu/hr verification test unit (VTU) using commercial design practices. Generic applications have been identified which include industrial heat pumping using reject heat, space conditioning, air or gas moisture removal, steam accumulation, cogeneration, and energy storage. The VTU design permits evaluation of two of the most

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* Reference "Energy User News," February 2, 1981, page 25.

PROGRAM STRUCTURE

$H_2SO_4/H_2O$ CHEMICAL HEAT PUMP/CHEMICAL ENERGY STORAGE SYSTEM

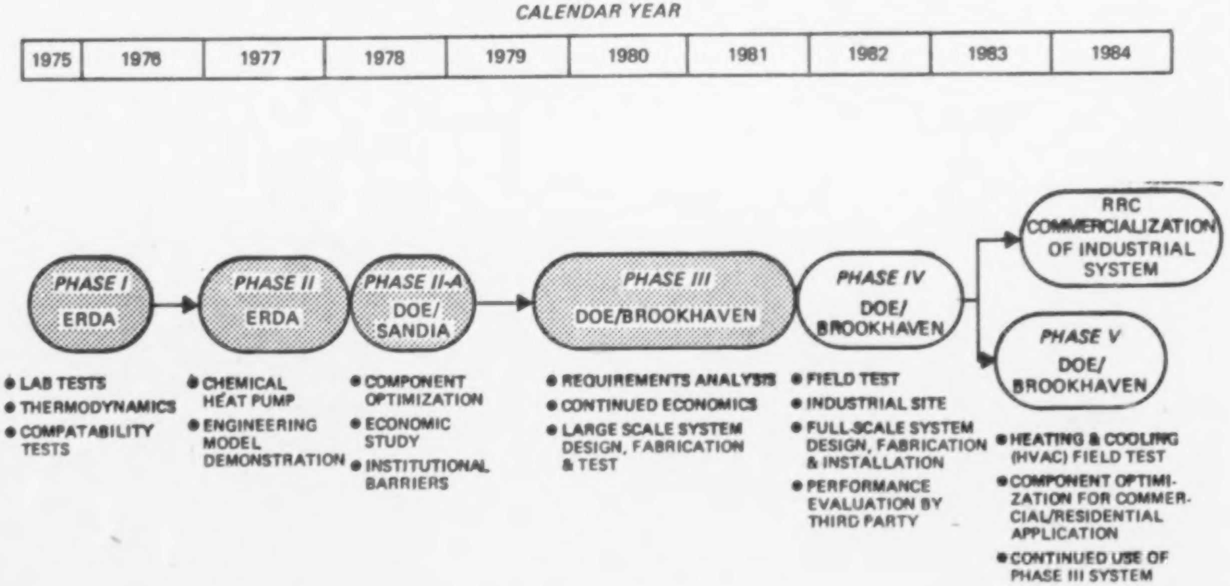

CALENDAR YEAR
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
PHASE I
ERDA
PHASE II
ERDA
PHASE II-A
DOE/
SANDIA
PHASE III
DOE/BROOKHAVEN
PHASE IV
DOE/
BROOKHAVEN
RRC
COMMERCIALIZATION
OF INDUSTRIAL
SYSTEM
PHASE V
DOE/
BROOKHAVEN
● LAB TESTS
● THERMODYNAMICS
● COMPATABILITY TESTS
● CHEMICAL HEAT PUMP
● ENGINEERING MODEL DEMONSTRATION
● COMPONENT OPTIMIZATION
● ECONOMIC STUDY
● INSTITUTIONAL BARRIERS
● REQUIREMENTS ANALYSIS
● CONTINUED ECONOMICS
● LARGE SCALE SYSTEM DESIGN, FABRICATION & TEST
● FIELD TEST
● INDUSTRIAL SITE
● FULL-SCALE SYSTEM DESIGN, FABRICATION & INSTALLATION
● PERFORMANCE EVALUATION BY THIRD PARTY
● HEATING & COOLING (HVAC) FIELD TEST
● COMPONENT OPTIMIZATION FOR COMMERCIAL/RESIDENTIAL APPLICATION
● CONTINUED USE OF PHASE III SYSTEM

Figure 1

promising near-term applications: waste heat pumping and space conditioning. The remaining Tasks 3 and 4, consisting of VTU fabrication and testing, respectively, are being conducted in FY '81.

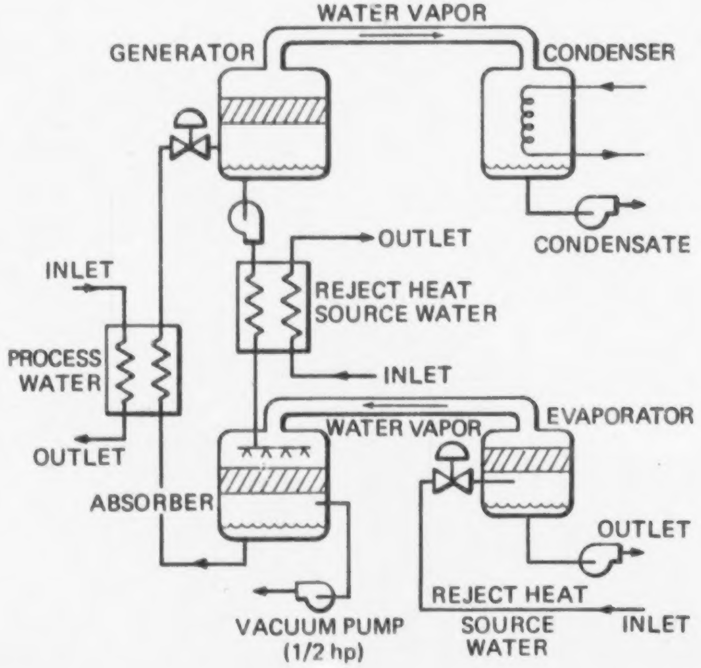
## SYSTEM DESCRIPTION

The chemical heat pump system is a high technology device. It can be configured to operate as either an energy storage device, or as a heat pump, or both. In its operation, a working fluid of concentrated sulfuric acid is diluted with water yielding heat which is then used for space (comfort) heating or for a process. The diluted working fluid is reconcentrated by distilling, using a reject heat source such as from an industrial process. Solar energy may also be used as an input energy source to drive the system. Because of the thermodynamics of the cycle, temperature amplification is achieved in its operation. Thus, with the heat pump, low-quality reject heat streams can be upgraded and restored to productive use, for example, in an industrial process. If the operational cycle is interrupted after the working fluid is reconcentrated, the chemicals can be retained in separate tanks until the user requires more heat. This latter case is an example of energy storage. In practice, heat pumping and energy storage can be provided in a single unit if required by the application.

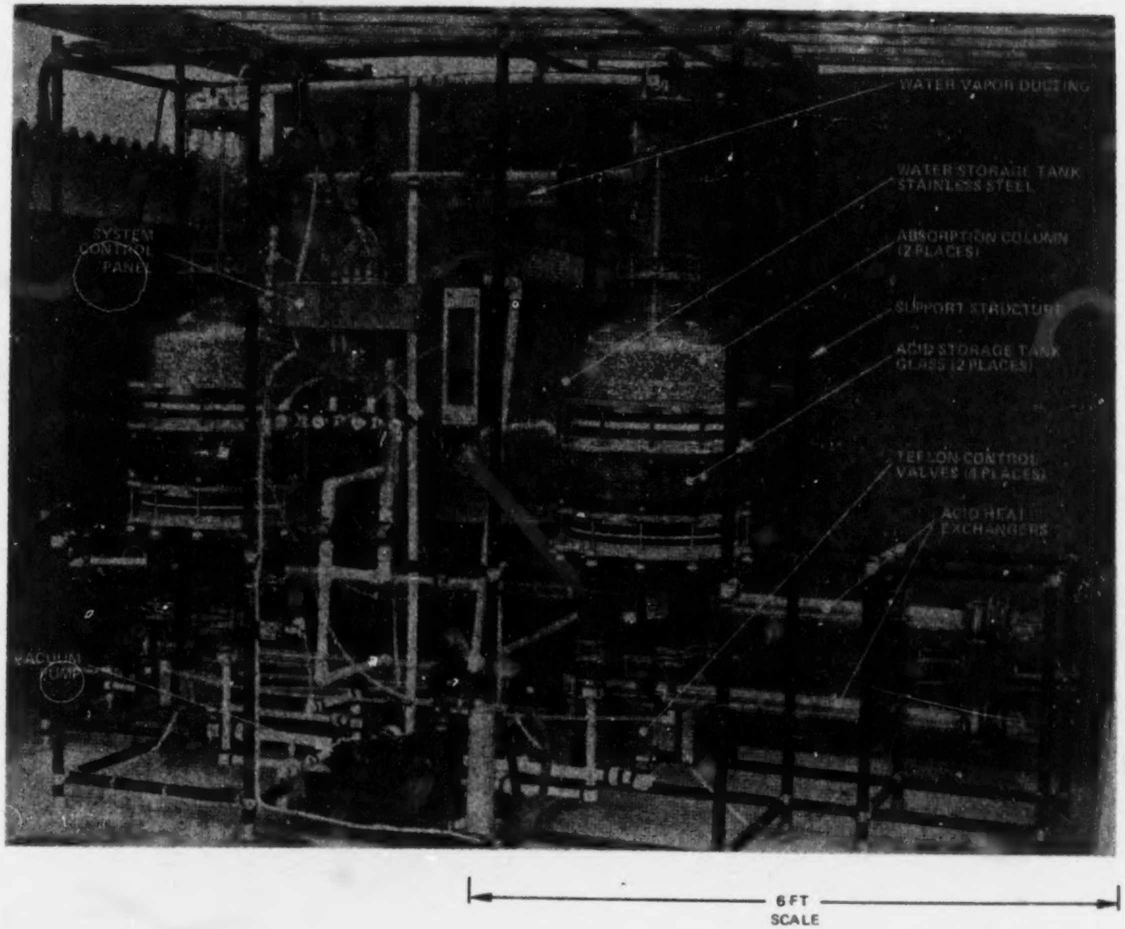
Figure 2 is presented without explanation simply to illustrate the complexity of the concept and to underscore the highly technical nature of one selected design. Figure 3 shows the developmental state of the device in the present engineering unit used for laboratory testing at the 25,000-Btu/hr output level. Under the present Phase III contract, a 150,000-Btu/hr test unit will be evaluated in FY '81. In the proposed Phase IV field test described in the next section, a 1 million-Btu/hr heat pump unit will be designed and tested at an industrial site. The Phase IV unit is sized to be in the minimum range of interest to an industrial user and represents a 40-to-1 scaleup from the experimental unit of Figure 3.

Heating and cooling of buildings and residences which includes energy storage continues to be an important application of the chemical heat pump. However,

## INDUSTRIAL CHEMICAL HEAT PUMP


WATER VAPOR
GENERATOR
CONDENSER
OUTLET
CONDENSATE
INLET
REJECT HEAT
SOURCE WATER
PROCESS
WATER
INLET
OUTLET
WATER VAPOR
EVAPORATOR
ABSORBER
OUTLET
VACUUM PUMP
(1/2 hp)
REJECT HEAT
SOURCE
WATER
INLET

CHEMICAL HEAT PUMP/CHEMICAL ENERGY STORAGE SYSTEM


WATER VAPOR DUCTING
WATER STORAGE TANK STAINLESS STEEL
ABSORPTION COLUMN (2 PLACES)
SUPPORT STRUCTURE
ACID STORAGE TANK GLASS (2 PLACES)
TEFLON CONTROL VALVES (4 PLACES)
ACID HEAT EXCHANGERS
SYSTEM CONTROL PANEL
VACUUM PUMP
6 FT
SCALE

29011-19 2018-1

Figure 3

the system requires a longer development period due to its added complexity. Therefore, the industrial heat pump has been given near-term priority for R&D.

## FUTURE PLANS AND PROGRAM RATIONALE

An industrial field test program is presently being planned for implementation during FY '82 (Ref. Figure 1, Phase IV). The program will consist of the design, fabrication, and testing of a chemical heat pump having an industrial capacity (about one million Btu/hr). The test will be conducted at a representative industrial plant and operated by plant personnel. The objective of the proposed program is two-fold: (1) design a full-size industrial chemical heat pump using scaling parameters evolved during previous development and (2) evaluate the technical and economic performance of the sulfuric acid system at a representative industrial site. The acquired information will serve as the basis for technical and economic performance projections for a wide variety of industrial applications of chemical heat pump technology. The proposed field test program cost is estimated to be $660,000, not including cost sharing.

This industrial test program is necessary before commercialization can occur because there is no industrial or public operating experience that certifies the chemical heat pump performance predictions, economics, and equipment safety. This is the risk. Public and industry acceptance will be positive if these factors are determined with field testing. Without a Federally funded field test program, the risk of commercialization due to this lack of operating experience is considered too great to proceed with industrial company funding alone. Future plans should also incorporate efforts to field test a solar-driven chemical heat pump/chemical energy storage system for residential and commercial use to maximize the range of applications and, thereby, the energy savings potential of this technology.

## REASONS FOR CONTINUED FEDERAL FUNDING

With the information gained from field test units to reduce the aforementioned risks, a commercialization plan can begin which will be greatly enhanced by the administration's policies of more rapid depreciation of equipment, tax credits and fuel price decontrol. The decontrol of fuel prices may or may not significantly increase the incentive to commercialize since the net effect of deregulation may be to stabilize energy prices. Since chemical heat pump economics are favorable compared to today's energy prices, RRC does not feel that decontrol will be a negative incentive to commercialize.

At the present time RRC is concerned that funding planned for the recommended field testing may be discontinued. This funding is needed to overcome the risks cited above. If funds are unavailable, the expected result is that the path to commercialization will be considerably lengthened with a real possibility that development will be stopped completely. Considering the potential energy savings in imported oil, combined with a modest cost to the government for R&D, RRC believes the current and projected DOE-funded program plan for chemical heat pumps, when carried through field testing, is extremely cost effective and will result in a significantly shorter time to achieve full commercialization as well as aid in assuring that commercialization will occur.

## THE BELLINGHAM DISTRICT HEATING SYSTEM DEVELOPMENT

Since 1977, a project has been underway to develop a district heating system for the City of Bellingham, Washington. The project is sponsored by the U.S. Department of Energy Division of Solar and Thermal Energy Systems, Office of Advanced Conservation Technology and administered through Oak Ridge National Laboratories. At the present time, the project is entering Phase III (Ref. Figure 4), which is the last phase in which DOE funding is planned. Phase IV is the full system implementation which will be financed locally and which includes planned partial payback to DOE for R&D equipment installed during Phase III activities. Lead investigation work for the project to date has been conducted by Rocket Research Company (RRC), a division of ROCKCOR, Inc. Support is being provided at no cost to the government by Intalco Aluminum Corporation of Ferndale, Washington, and by the City of Bellingham. Costs of Intalco and city activities are provided as cost-sharing to the project by each organization.

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PROGRAM OVERVIEW
BELLINGHAM DISTRICT HEATING SYSTEM
UTILIZING RESIDUAL HEAT FROM INDUSTRY

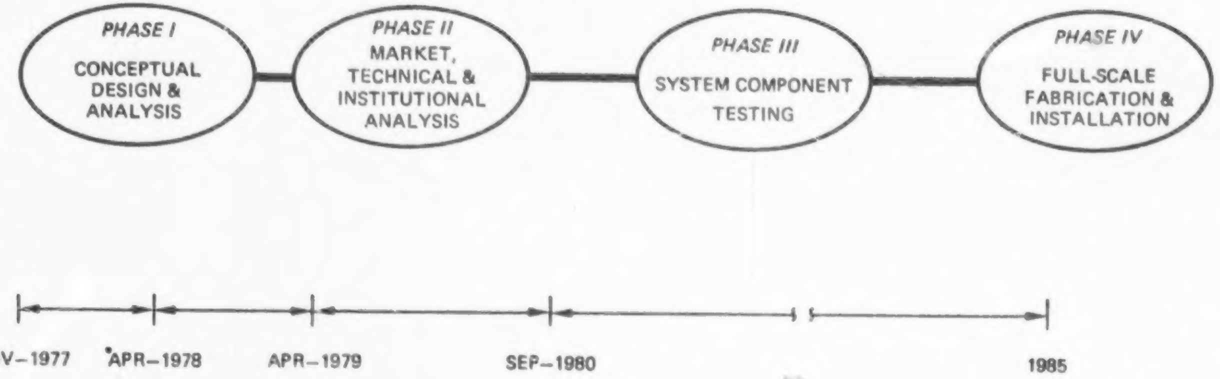

*PHASE I*
CONCEPTUAL DESIGN & ANALYSIS
*PHASE II*
MARKET, TECHNICAL & INSTITUTIONAL ANALYSIS
*PHASE III*
SYSTEM COMPONENT TESTING
*PHASE IV*
FULL-SCALE FABRICATION & INSTALLATION
NOV–1977
APR–1978
APR–1979
SEP–1980
1985

Figure 4

In two key technical particulars, this project differs from most district heating systems developed previously in Europe or presently under consideration in several U.S. cities. First of these is the proposed use of reject industrial process heat as the energy source and second is the plan to designate a service area where almost 80 percent of subscriber structures are single-family residences. Either or both of these characteristics are foreseen at many other candidate district heating sites as the technology spreads across the United States in the coming years.

Two other unique nontechnical features of this project are the inclusion of user retrofit costs as a capital expense of the system to encourage hookup, and an agreement by the City to repay DOE for portions of the R&D when the full-scale system is implemented. These features, as well as the two aforementioned items, combine to introduce an element of risk since the precedents are not well established in prior experience. Continued Federal funding support of this project through Phase III, therefore, is essential to project success to complete the risk mitigation process.

The following paragraphs develop the potential impact of this project on national energy consumption, the project plan, a technical description of the project, and the reasons why continued Federal funding is necessary when policy is changing to encourage more private involvement in energy conservation technologies.

## NATIONAL ENERGY IMPACT

The Bellingham district heating project will utilize approximately 44 megawatts of reject industrial heat for the end use of community space heating and domestic hot water production. Full-scale implementation of this project will result in displacement of electrical, oil and natural gas usage equivalent to 200,000 barrels of oil annually. A few further statistics underline the potential national impact of this project. Energy utilized in the United States by the industrial base is approximately 40 percent of the total national energy consumption. In an industrial process, this heat is used and the temperature reduced to a point where it has no further use within the plant, and thence is rejected to the atmosphere. About 85 percent of industrial energy consumption is eventually rejected in this manner. The rejected energy does, however, have sufficient utility to be applied to low temperature uses such as community space and water heating. Not all industrial reject heat can be feasibly recovered. Taking only that fraction which is recoverable with current-day technology, it is estimated that five to eight quads (5 to 8 X $10^{15}$ Btu) of energy (over 85 percent of which is oil and gas) can be displaced annually from the space and water heating demands of the United States using reject industrial heat. This represents over 1,000 million barrels of oil per year, or approximately 10 percent of the country's total annual energy demand. Actual gas and oil displacement would be about 2 to 3 million barrels of oil per day, or over 25 percent of oil imports. The potential benefits of widespread implementation of this technology are clearly significant and desirable.

## PROJECT PLAN

The project began its first phase in 1977 (Ref. Figure 4) with a survey of the primary aluminum industry nationwide. The technical and economic results of this survey showed preliminary technical feasibility and preliminary economic viability, not only for the aluminum industry, but for all low-temperature industrial reject heat. District heating of homes and commercial establishments was identified as the most cost-effective application for the identified waste energy streams. In this concept, energy storage plays an important role by providing a buffer between the constant industrial reject energy supply and the varying community energy demand.

The city of Bellingham provides an ideal setting to unite the concept of district heating with the concept of industrial reject heat recovery. Bellingham has an unusually active citizenry taking a positive interest in community affairs. This factor was a strong contributor to Bellingham receiving an all-American city award from the National Municipal League, one of only nine such awards made nationwide. This citizenry has a demonstrated interest in environmental protection and energy conservation, which provides a good participation context for testing the energy-conserving technology represented by the hot water district heating system.

The city is located approximately 10 miles from the identified reject energy source. This distance is typical of many large industry/urban-core pairs in the United States.

The climate of Bellingham is relatively mild. The average annual heating season is 5,738 degree days, which is near the national average. More severe climates will show even better economic results; hence, Bellingham provides a conservative example site.

The present city administration is committed to revitalizing public housing and public service structures within the urban core. The proposed district heating system complements this activity and is thus in harmony with city renewal plans. The Mayor and City Council of Bellingham have placed this project and related energy issues on the public policy agenda, and thereby have given the project a continuity and political strength beyond what might be their individual political tenures.

During the second phase of the project, the example site of Bellingham coupled to Intalco Aluminum Company was examined in considerable detail. Key areas of investigation were (1) demographics of the market area, (2) equipment technology and supply, (3) additional energy sources, (4) institutional, legal and environmental conditions, and (5) more detailed economic evaluation. Each of these areas of investigation contributed additional accuracy to the performance and economic forecasts and institutional characterization, thereby improving the level of confidence in project feasibility and cost effectiveness.

Phase III of the project is underway presently. In Phase III, a small-scale district heating system will be installed in the selected service area to provide an assessment of the projected performance and costs and to serve as a community model to facilitate hookups in the full-scale system. This small-scale (100-structure) unit will become an integral part of the Phase IV full-scale (3,000-structure) system. In parallel, one of the eventual 12 full-scale reject heat recovery heat exchangers will be designed, fabricated, installed and tested at the Intalco plant to confirm its compatability with plant systems and operations and to validate its performance and costs. Further, selected detail engineering to support development of the bond issue in Phase IV will be completed. These activities will cover the next 39 months thus extending into FY '84.

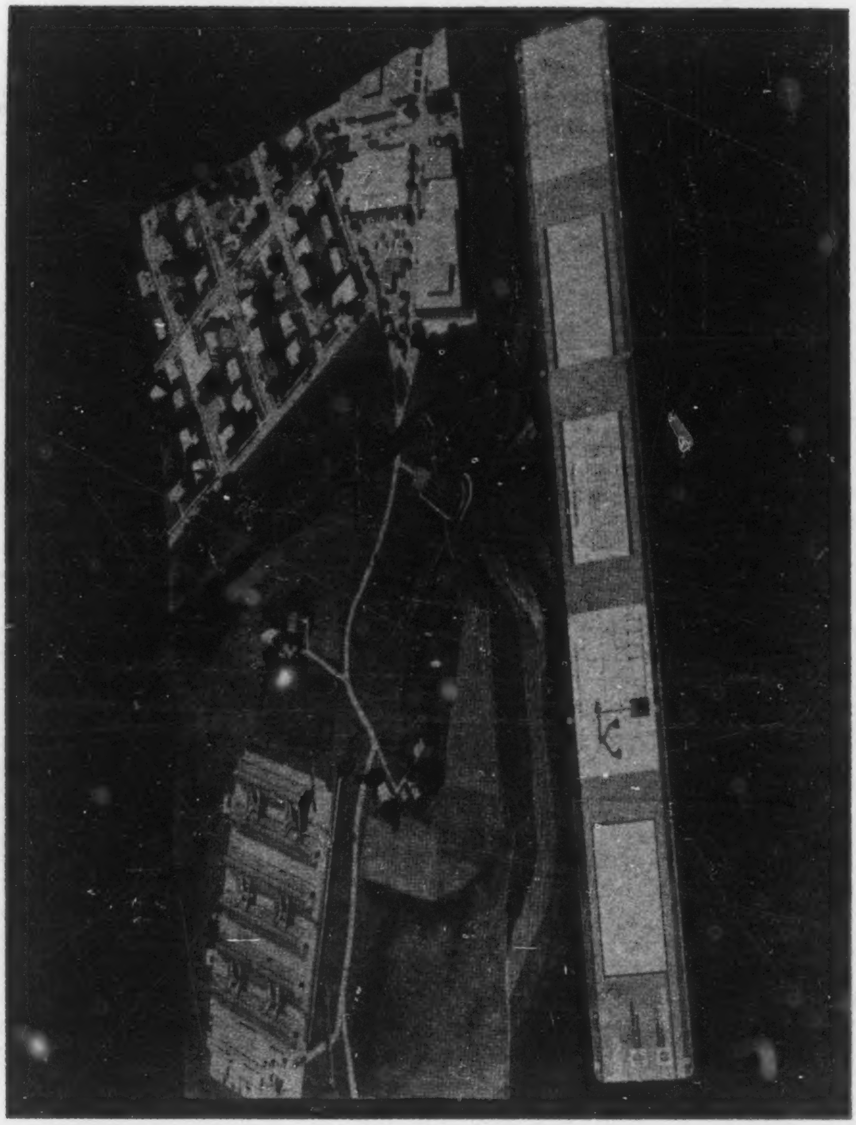
Additionally, as a part of Phase III, Intalco and the City of Bellingham have executed a Memorandum of Understanding (Ref. Attachment A) with the Department of Energy detailing their support, participation, willingness to cost share, and payback provisions. The City has retained bond counsel and executed an agreement with national and regional investment banking firms to assist with developing a financing plan beginning with this early stage of the project. Legislation clarifying municipal ownership of a district heating system has passed the State Senate and is currently before the State House of Representatives. This legislation will facilitate implementation of the full-scale district heating system. Bellingham has established and staffed a district heating office. A community Advisory Group with diverse members of the community has been meeting for the last 18 months and continues to provide direction and linkage with major sectors of the public.

The fourth project phase will continue with city-arranged financing. A municipal utility will secure financing through the issuance of a mix of revenue and general obligation bonds to fund the full system construction. It is the stated intent of parties concerned that Phase III funds which are applied to hardware later incorporated in the full-scale system will be repaid from Phase IV revenues.

## TECHNICAL SYSTEM DESCRIPTION

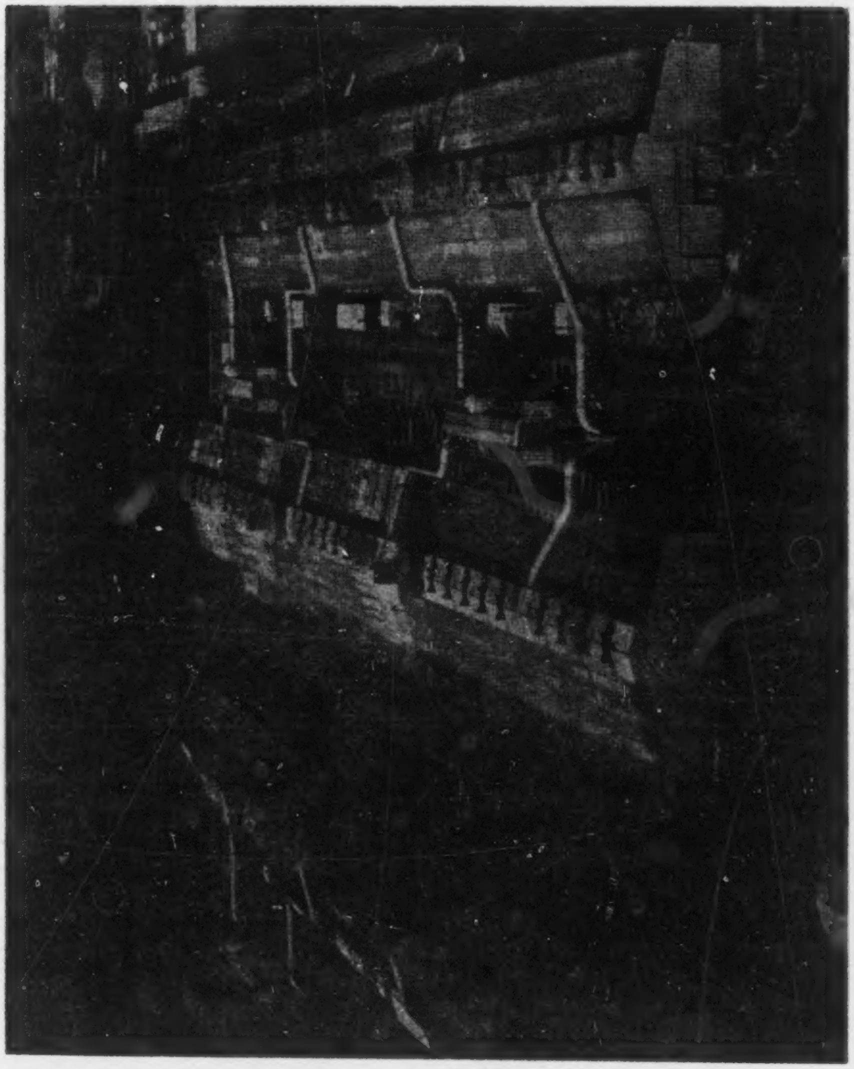
Figure 5 is a photograph of a semi-schematic model developed of the system. The proposed district heating system for Bellingham is based on the recovery of reject process heat from the production of aluminum at the Intalco Aluminum Plant (Figure 6) at nearby Ferndale. This reject heat will be used to heat water which will then be pumped to a heat storage and peaking boiler plant located near the Bellingham airport via an 11-mile transmission pipeline. The project

MODEL OF PROPOSED BELLINGHAM DISTRICT HEATING SYSTEM



29018-68

Figure 5



AERIAL VIEW – TYPICAL INTALCO POTLINE

Figure 6

has placed special emphasis on evaluation of thermal energy storage alternatives to link the constant industrial heat source with the varying community thermal demand over time. In addition to the use of insulated surface tankage proposed for the baseline system, underground aquifers and an abandoned coal mine under Bellingham have been examined as candidate energy storage systems.

To provide for the small percentage of time that consumer heating demand exceeds available heat recovered from Intalco, and to provide a system backup, a fossil fuel-fired peaking boiler is included. Thermal energy storage will be utilized to minimize the consumption of fossil fuel by buffering normal swings in consumer heating demand. From the peaking and storage plant, hot water will be distributed to consumers in the community through a network of district heating mains, piping networks, metering stations and ancillary equipment. The Bellingham district heating system service area includes a variety of structures, many of which are single-family residences. To serve as many consumers as possible while optimizing distribution network costs, boundaries of the "baseline" service area were carefully drawn to cover structurally concentrated portions of contiguous neighborhoods.

## REASONS FOR CONTINUED FEDERAL FUNDING

Although basic hot water district heating technology has been in use in Europe for a number of years, its transposition to the U.S. involves risks to the implementing parties. These risks arise in the present program in both the city of Bellingham and industrial energy source portions of the system.

The industrial partner, Intalco Aluminum, must be assured that the plant processes will not be adversely affected by the installation and operation of the reject heat recovery equipment. The aluminum reduction process must not be affected and the plant primary air pollution control system must continue to perform within specification. For both the industry and the city, the heat recovery equipment performance must be confirmed in the operational environment to provide the required utility-level confidence in the heat source availability. From the City's standpoint, to secure Phase IV financing, not only must the energy source be secure, but also the energy market which will provide debt retirement must be assured.

The Phase III program now underway on a cost-shared basis with DOE funding is designed to minimize or eliminate these risks to the satisfaction of all involved parties -- industrial, city, Federal and bond counsel. Interruption of the funding from DOE would stop the project due to lack of local funds to carry through this risk phase. Considering the exceptional nationwide energy-saving potential of this reject heat recovery/district heating technology and the need to encourage its widespread implementation, every effort should be made to assure continuity of funding of the Phase III work through DOE as presently planned.

ATTACHMENT A

# MEMORANDUM OF UNDERSTANDING
FOR A
JOINT VENTURE PROJECT
BETWEEN
UNION CARBIDE CORPORATION
NUCLEAR DIVISION
AND
CITY OF BELLINGHAM
AND
INTALCO ALUMINUM CORPORATION
FOR
INDUSTRIAL HEAT RECOVERY SYSTEM EMPLOYING
ENERGY STORAGE TO PROVIDE HOT WATER DISTRICT HEATING TO
THE CITY OF BELLINGHAM, WASHINGTON

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THIS JOINT VENTURE is effective the 1st day of December, 1980, except as hereinafter specifically provided, between UNION CARBIDE CORPORATION, NUCLEAR DIVISION, a corporation organized and existing under the laws of the State of New York with a principal office at 270 Park Avenue, New York, New York 10017 (hereinafter referred to as "UNION CARBIDE") acting under its Prime Contract W-7405-Eng-26 with the UNITED STATES OF AMERICA as represented by the DEPARTMENT OF ENERGY (hereinafter referred to as "DOE" or "GOVERNMENT") and THE CITY OF BELLINGHAM, incorporated under the laws of the State of Washington (hereinafter referred to as "CITY") and INTALCO ALUMINUM CORPORATION, a corporation organized and existing under the laws of the State of Delaware with a place of business located at Ferndale, Washington (hereinafter referred to as "INTALCO")

WITNESSETH THAT:

WHEREAS, the CITY and INTALCO are uniquely situated to enable the CITY to utilize the industrial recoverable heat from INTALCO's plant at Ferndale for a hot water district heating system within the city limits; and

WHEREAS, DOE in Phase I of this project has made a general study of the feasibility of utilizing industrial recoverable heat; and

WHEREASE, UNION CARBIDE acting for and on behalf of the DOE is desirous of furthering this utilization of industrial recoverable heat with technical and financial support; and

WHEREAS, under Phase II of this project UNION CARBIDE has entered into Subcontract No. 86Y-42535C with Rocket Research Company, a division of ROCKCOR, Inc., to evaluate the technical and economic feasibility of an industrial recoverable heat recovery system employing energy storage, for the purpose of providing hot water district heating to the CITY; and

WHEREAS, under Phase III the project will be continued by Union Carbide through its subcontractors Trans Energy Systems, Inc., and the Rocket Research Company to more completely characterize the industrial plant energy recovery equipment, the user market equipment, the transmission and distribution network, alternative energy sources and thermal energy scheme, by providing the necessary engineering for the CITY's hot water district heat system and demonstration of a segment of the eventual full scale system in the CITY; and

WHEREAS, UNION CARBIDE is willing to enter into a development and demonstration program, through its subcontractors, to provide INTALCO and the CITY the necessary demonstration equipment to enable INTALCO and the CITY to determine the feasibility of using industrial residual heat for furnishing the CITY hot water for district heating purposes; and

WHEREAS, it is contemplated that the CITY will establish a municipal utility to finance, construct and operate the hot water district heating system within the framework of its existing Governmental structure;

NOW, THEREFORE, the parties hereto agree as follows:

## ARTICLE I -- STATEMENT OF WORK

UNION CARBIDE will subcontract with Trans Energy Systems, Inc., to provide all engineering and technical assistance to the CITY for a hot water district heating system and demonstration of a segment of the contemplated full scale system in Bellingham. UNION CARBIDE's obligation is more fully detailed in the statement of work identified as Exhibit II which is attached hereto and made a part hereof.

UNION CARBIDE, through a parallel subcontract with the Rocket Research Company, will design, develop, fabricate and test heat exchanger equipment associated with waste heat recovery at the INTALCO plant. The statement of work is identified as Exhibit III and is attached hereto and made part hereof.

INTALCO agrees to assist the Rocket Research Company in the heat exchanger program by furnishing necessary technical data and providing UNION CARBIDE and its subcontractors access to its Ferndale plant facilities in accordance with the terms set forth in a Rocket Research/INTALCO contract. Upon demonstration, to the satisfaction of INTALCO, that the full scale heat exchanger operation and performance are feasible and if at that time INTALCO desires to continue the program INTALCO will enter into a separate agreement with the CITY to furnish hot water to the CITY.

The CITY agrees to cooperate with the Parties by furnishing the necessary data and access to its premises and facilities to enable the other Parties to complete their obligations in this project. Upon the completion of the demonstration segment, Phase III, of the hot water district heating system, as set forth in Exhibit II and Exhibit III, neither UNION CARBIDE, DOE, nor the CITY shall be under any further obligation to provide additional services. This agreement shall terminate unless amended by the parties. Should the CITY decide to provide a full scale system, it will do so on its own.

## ARTICLE II -- PROGRAM MANAGEMENT

Program coordination of the work to be performed by the Parties hereunder will be accomplished by a Program Management Organization with interrelationships as set forth in Exhibit I, which is attached hereto and made a part hereof.

It is the intent of the Parties that the majority of the work to be performed hereunder shall be carried out by the Union Carbide subcontractors. For purposes of administrative efficiency and convenience, the Parties have agreed that UNION CARBIDE or its authorized representative shall, within the constraints imposed by this Memorandum, administer all aspects of this agreement, except as otherwise specifically provided.

In recognition of the Parties' cost sharing of this project, and notwithstanding the last sentence of the immediate paragraph above, UNION CARBIDE hereby agrees that prior to issuing any change orders or technical direction for its contracts with Trans Energy Systems and Rocket Research Company which will affect the interests of Intalco or the City, Union Carbide shall obtain the written concurrence of the other Parties' representative designated in writing to UNION CARBIDE, who is authorized to act for and on behalf of the other Parties; provided, however, that with respect to technical directions the prior concurrence of the other Parties may be oral (if reduced to writing later) and, provided further, that any necessary concurrences shall not be unreasonably withheld. Technical matters that are informational in nature may be discussed independently with other Parties' personnel by telephone or personal visits without obtaining concurrence of the other Parties.

Technical direction must be within the general scope of work stated in Article I above. UNION CARBIDE does not have the authority to and may not issue any technical direction which (i) constitutes an assignment of additional work outside the general scope of Article I above; (ii) in any manner causes an increase or decrease in the total estimated contract cost or the time required for contract performance; or (iii) changes any of the expressed terms, conditions or specifications of the agreement.

## ARTICLE III -- PERIOD OF PERFORMANCE

Union Carbide's past participation in this work is described more fully in Subcontract No. 86Y-42535C as amended which began April 2, 1979, and will continue hereunder to completion thereof, estimated to occur on or about November 30, 1980. Union Carbide's future participation in this work (Phase III) as more fully described in the Exhibits II and III will be performed over a 42-month period commencing December 1, 1980.

## ARTICLE IV -- ESTIMATES OF COST, COST SHARING, OBLIGATION OF FUNDS AND FINANCIAL LIMITATIONS

a. The presently estimated cost of the project under Phases I, II, III is $7,621,814.

b. The presently estimated cost of the Phase II work performed by UNION CARBIDE on this project is $1,014,651.

c. The presently estimated contribution by INTALCO through Phase III under this project is $300,000.

d. It is presently estimated the CITY could expend up to $73,000 through Phase III as its contribution.

e. Upon the successful demonstration of the small scale district heating system set forth in Phase III of this project it is presently estimated the CITY could expend up to $110 x 106 on a future full scale district heating system using recoverable heat furnished by INTALCO.

## ARTICLE V -- COST SHARING AND WITHDRAWAL OF PROJECT SPONSORSHIP

Each Party will be solely responsible for costs it incurs with respect to its portion of the project. Should any Party decide to withdraw from the project and terminate its portion of the work the terminating Party shall notify the other Parties in sufficient time prior to such termination that suitable arrangements can be made by the remaining Parties to minimize their expenses.

Should UNION CARBIDE, at the direction of DOE, withdraw from the project set forth in this Memorandum such withdrawal would be in accordance with those terms of the UNION CARBIDE subcontracts identified as "Termination for Convenience of the Government."

In the event UNION CARBIDE is directed by DOE to withdraw its support of this project, or at the termination of this agreement, the other Parties may elect to purchase all or any part of the GOVERNMENT Property furnished the other Parties by UNION CARBIDE under the aforesaid subcontracts at prices to be agreed upon, or UNION CARBIDE may elect to abandon such property in accordance with subparagraph (j) of Article 12 entitled Government Property in the terms of the UNION CARBIDE subcontracts.

## ARTICLE VI -- KEY PERSONNEL

The key personnel to this agreement are:

| | | | |
|---|---|---|---|
| UNION CARBIDE | A. F. Johnson | M. Olszewski | |
| CITY | Pat Brock | Jean Gallegos | Jerauld Fry |
| INTALCO | Robert Ferrie | Peter Aylen | Stanley Cheatham |

## ARTICLE VII -- AGREEMENTS WTH CUSTOMERS

The CITY will be responsible for obtaining the necessary agreements with Customers provided service by this project. These agreements will cover, but not be limited to, the (1) right of entering, (2) liability, (3) sale of home, and (4) payment for hot water.

## ARTICLE VIII -- REPAYMENT BY CITY TO DOE

Should the CITY enter upon a full-scale project of district hot water heating after Phase III is completed, the CITY agrees to repay DOE only for that hardware actually incorporated in the full-scale project which was paid for by Union Carbide on behalf of DOE. DOE agrees to convey title to said hardware to the CITY. Such repayment by the CITY will be made from revenue the CITY receives from its hot water customers after the CITY has deducted its expenses for furnishing the hot water. Such expenses shall include, but not be limited to, interest and payment on the bonded or other indebtedness incurred by the CITY to furnish hot water to the customer.

The obligation to make repayment under the preceding paragraph shall terminate when the aggregate of the amounts paid by the CITY to DOE equals the total amount UNION CARBIDE expended on behalf of DOE for hardware under this project or any future amendments hereto.

In no event will the CITY be obligated to make repayments to DOE after December 31, 1995.

Any financial reporting would be the subject of the separate agreement entered into between the CITY and DOE after the completion of Phase III.

Under no conditions shall this provision be construed to require the CITY to set user rates which make the system uncompetitive with other sources of heat available to potential users of the system.

## ARTICLE IX -- CONDUCT OF EMPLOYEES

The Parties shall be responsible for maintaining satisfactory standards of employee competency, conduct, and integrity and shall be responsible for taking such disciplinary action with respect to their employees as may be necessary.

## ARTICLE X -- PATENTS, COPYRIGHTS AND TECHNICAL DATA

Exhibit IV sets forth the rights of the Parties to any technical data and to inventions made or conceived in the course of or under any subcontract entered into with or for the benefit of DOE under the Memorandum of Understanding. These articles will be incorporated into any lower tier contract UNION CARBIDE entered into for this project and are also made part of this Memorandum of Understanding.

EXECUTED this 29 day of Dec., 1980, for UNION CARBIDE CORPORATION NUCLEAR DIVISION:

By: B. B. Osborne

Title: General Purchasing Agent

EXECUTED this 2nd day of December, 1980, for INTALCO ALUMINUM:

By: Peter E. Ayler

Title: VP - Plant Manager

EXECUTED this 26th day of November, 1980
for the CITY OF BELLINGHAM:

Ken Hertz
Mayor

Attest: S.K. Hoffman
Finance Director

Approved as to Form:

City Attorney's Office

Departmental Approval:

Jean Gallagher

Approved:

U.S. DEPARTMENT OF ENERGY

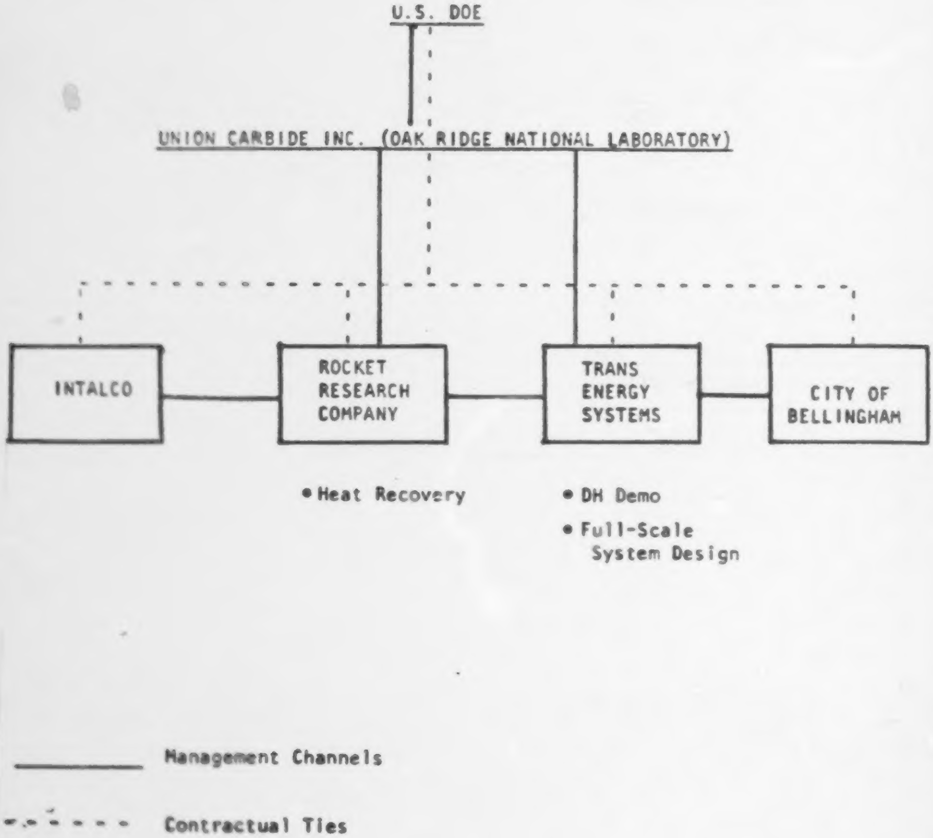
By: Willis Davis

Title: CONTRACTING OFFICER

Date: FEB 27 1981

## EXHIBIT 1

## PROGRAM MANAGEMENT ORGANIZATION


U.S. DOE
UNION CARBIDE INC. (OAK RIDGE NATIONAL LABORATORY)
INTALCO
ROCKET RESEARCH COMPANY
TRANS ENERGY SYSTEMS
CITY OF BELLINGHAM
• Heat Recovery
• DH Demo
• Full-Scale System Design
Management Channels
Contractual Ties

## ATTACHMENT B

**WILLIAM F. THORN**
Director, Energy R&D
Rocket Research Company

### EDUCATION

University of New Mexico
BChE 1956

### PERSONAL

Birthdate..........July 23, 1935
Clearance.................Secret
Military...............U.S. Navy

### EXPERIENCE SYNOPSIS

18 Years Managerial
17 Years Propulsion
24 Years Engineering

| | |
|---|---|
| 1979-Present | Director, Energy R&D |
| 1978-1979 | Senior Staff Engineer, Energy R&D Deputy Manager, Petroleum Technology |
| 1971-1977 | Director, Commercial Programs |
| 1969-1971 | Director, New Product Development |
| 1965-1969 | Manager, Undersea Technology |
| 1964-1965 | Aerospace Engineer, Propulsion Development |
| 1963-1964 | Branch Head, Ballistic Test |
| 1961-1963 | Sr. Test Engineer, Liquid Propellants |
| 1959-1961 | Project Engineer, Rocket Programs |
| 1957-1959 | U.S. Navy, Polaris Propulsion Officer |

### PROFESSIONAL EXPERIENCE

Rocket Research Company (April 1965-Present)

Director, Energy R&D - As Director, Energy R&D, Mr. Thorn is responsible for all aspects of the operation of the department. This responsibility includes planning, staffing, budgeting, direction, and new business activities covering a wide range of technical work. Typical projects within the group include studies and developments in electrical/thermal cogeneration systems, district heating systems, waste heat recovery systems, solid waste recovery systems, energy storage systems, chemical heat pump systems, and corporate energy planning services. Projects include energy use/loss and resource surveys, energy market surveys, component and systems engineering synthesis and design, institutions and regulatory evaluations, life cycle cost and economic analyses, and construction definitions. Engineering includes process design and the selection and sizing of equipment and systems for energy facilities of all types. Customers include private industry, federal, state, and local government entities and utilities.

Senior Staff Engineer, Energy R&D - As the senior staff engineer in the Energy R&D Department, Mr. Thorn carried out the technical portions of two major energy programs. These programs entailed detailed on-site chemical engineering evaluations of the 150 largest energy consuming industrial firms from 26 industry sectors in the tri-state Pacific Northwest region. These studies provided plant process and energy use/loss characterizations, energy recovery and electrical/thermal cogeneration system syntheses, and life cycle economic analyses. The resultant data base and analysis reports provide a unique insight into regional industrial energy use and recovery potential and the cogeneration potential from the industrial base. Throughout this same period, Mr. Thorn both originated and participated in key new business activities of the Energy R&D Department.

Deputy Manager, Petroleum Technology - In this position, Mr. Thorn originated and directed new downhole equipment developments and evaluations associated with the proprietary Astrofrac II oil and gas well explosive stimulation process. In addition, Mr. Thorn carried out the detailed thermal analysis of the multicomponent pipe string used in the process to manufacture and deliver the liquid explosive to the formation to be fractured. This analysis provided the basis for field operating procedures under a wide ranging set of wellbore conditions to assure proper and safe downhole explosive manufacture.

Director, Commercial Programs - As director, commercial programs, Mr. Thorn was responsible for commercialization of products intended principally for non-government markets. This responsibility extended from development through full-scale production, including economic analyses of markets and penetration, product production costs, production facility, equipment and tooling costs, and return on investment studies. Heavy emphasis in this position was placed on the Boeing 747 Cool-Gas Inflation System production program and new product developments in the field of passive automotive crash restraint inflation systems. He managed all company work on solid propellant inflator/restraint module development for passive restraint systems, made major design contributions to these developments, was co-inventor on inflator patents, and participated in dynamic testing for these devices. In addition, Mr. Thorn consulted within the company on energy product research and technology projects as these areas progressed towards commercialization.

Director, New Product Development - In this position, Mr. Thorn was responsible for carrying out the in-house development of new products, including their analysis, design, prototype manufacturing and testing. Additional responsibilities included the identification and evaluation of new product concepts, preliminary design, materials and process technology, and model shop support for the R&D department.

Major accomplishments of this group included the design and development of the advanced Mark X family of cool-gas inflation systems, the development of two advanced, high performance aspirators, the development of two types of automatic igniters for orchard heating systems, the generation of numerous new concepts to support other new business proposal activities, and substantial engineering development work on inflation systems for automotive crash restraint systems.

Manager, Undersea Technology - In this capacity, Mr. Thorn was responsible for formulating and carrying out the company's new business program in the field of undersea technology. Efforts centered around the application of hydrazine gas generators in the undersea environment.

In addition to this primary responsibility, Mr. Thorn was an active participant in the company's overall new business efforts. He participated in various positions of responsibility including management of large new business proposal efforts and contributed to the development of the company's management system. Mr. Thorn's responsibilities have included advanced hydrazine reactor development aimed at future new business applications.

## U.S. Naval Ordnance Test Station China Lake (1959 - 1965)

At NOTS, Mr. Thorn worked in a number of positions of progressively increasing responsibility. Significant among these positions were those of Polaris project engineer; test engineer in charge of installation and operation of the Skytop vertical high-altitude test facility; senior test engineer in charge of the liquid test facilities; branch head, ballistic test branch, in chrage of station static test facilities with approximately 45 engineering and ordnance personnel; and program manager for a broadly based liquid monopropellant technical development program. During his employment at NOTS, Mr. Thorn was the recipient of several superior performance awards.

## U.S. Navy (1957-1959)

Mr. Thorn's naval service included the responsibilities of propulsion officer on the Polaris program at the navy field office in Sunnyvale, California.

Mr. WOLPE. Thank you very much.

I think before turning to questions we will take the testimony of Dr. Lawrence.

Mr. LAWRENCE. Thank you, Mr. Chairman and members of the subcommittee.

My written statement has been submitted to you.

As background, my career has been directed to interpreting power industry transmission and distribution systems development and trends. I am particularly concerned with anticipating future system needs for the development and application of power systems equipment. As a fellow of the Institute of the Electrical and Electronic Engineers, I am presenting some views on behalf of the Energy and Research and Development Committees of IEEE.

I would like to present a few of the main points that I have submitted in my written statement. It is my understanding that this portion of the fiscal year 1982 budget on which I am commenting is subject to a proposed cut from $38.9 million to $9 million. I am not in a position to assess the amount of the budget cuts, nor to assess whether the final level is appropriate.

I do not oppose the funding of long-term, high-risk projects. In fact, I agree with their support and indeed raise the question whether $38.9 million is an adequate R. & D. expense for the specifics proposed, in the light of the capital investment of the total energy business.

An extremely significant part of the EES program is power delivery and related program elements. If we are to deal successfully with the energy problem we simply must start at one very important source, the generation of electric power. But, with equal priority, we must have the capability of delivering that electric energy through transmission and distribution lines, and it necessarily follows that we must be able to solve the problems that reliable power delivery requires.

I cite the example of high voltage transmission, particularly transmission at 1200 kV, which is referred to as ultra high voltage (UHV). It is apropos to make some brief reference in this summary.

The example of UHV is apropos to focus on broader problems that the subcommittee must consider. It and similar technologies identified in the EES programs have international attention, for example, U.S.S.R., Sweden, France, Germany, Italy, Japan, Canada, Brazil, Australia, to name a few.

The U.S. need for UHV is beyond 10 years into the future. In an earlier day, the U.S. private sector could have supported the R. & D., and did. This is as it should be.

But today the private sector cannot support this R. & D. and still realize the necessary return. One source of funding is the DOE to provide support to R. & D. now so that technology is available when it is needed, and to develop and maintain U.S. human resources to compete in the international marketplace. If the United States does not sustain the technology now, it will be too late in 1982 or 1983 or 1984, much less 1990, when other countries have already long supported the R. & D.

DOE financial support is an alternative for the long-term, high risk projects. The United States must lead in technology through R. & D. in industry, and the universities. To lose position will only exacerbate the scenario of lower standards of excellence in U.S. science and engineering, enhance offshore competition and eventual influx of non-U.S. products into the United States to the devastation of the U.S. economy.

We can already see the effects today of this scenario in the short term. Industry and the scientific community are attacking it to regain our competitive edge. The issue we are dealing with here is time. We must buy "research futures". Somehow, the seed money must be made available to reap the technical crops of the future.

The pattern that seems to have developed in DOE is to choose projects which fit the long-term, high risk category and then support them through demonstration projects, "fait accompli". Of course, the importance of the first step is obvious, that is, the selection of a project that is worthy of taking through the demonstration stage. Then, when the project has been successfully demonstrated, information should be available for dissemination so that the private sector can take over.

I have in my written statement reviewed several programs, and I cite them here.

System control and development; it is extremely important to recognize that the programs there are directed toward power system reliability. It is also important to point out that the United States has always had the highest power system reliability of any country in the world.

There are a number of programs in new technology innovation, and some are listed in the fiscal year 1982 budget.

There is no particular one that I concentrate on but, an example is fuel cells which is very important because it not only generates electric power but relates also to the transmission and the distribution of power.

Load management is a demonstrated project. Power delivery, which refers to transmission problems, has been addressed in reference to ultra high voltage.

An alternative to transmission overhead is underground transmission, and some of the program is concerned with this.

There are problems which the use of overhead transmission creates. Underground transmission has characteristically been an alternative. However, the cost ratio of underground to overhead, is as high as 20 to 1 is an obvious deterrent.

As to high voltage direct current technology, there are a couple of points that I think are worth bringing out here. Swedish and German based companies and one U.S. company have invested heavily in U.S. technology in the private sector. R. & D. funding is proposed to support HVDC. For example, a circuit breaker is a long-term but low-risk venture in terms of its chance of success, there is some question of whether or not it will be used, which illustrates the risk that industry must take.

The electric field effects of high voltage transmission is important because of some ambiguity with respect to the demonstration criteria. One can demonstrate a project which has been done, but with respect to electric field effects created by the use of overhead high voltage transmission, there is what I call a morality issue. Field effects can impact on the people environmentally.

So the problem that I think needs to be solved here is to discover and document the information, so that the private sector can comply and set up standards and comply with those standards. I think that step would happen.

In high voltage a.c. technology the control of systems, and the advancement of proven systems and networks that are already in existence is an extremely important concern. They support the generating plants that transmit power from hydro, coal, and nuclear to the urban centers.

It is an honor to have this opportunity to present these views for the IEEE and I would be glad to answer any questions that I can.

[The prepared statement of Mr. Lawrence follows:]

# Statement to House Subcommittee on Energy Research and Production

R. F. Lawrence
March 16, 1981

My name is R. F. Lawrence. Since 1943 my entire career has been in the field of electric power systems. More specifically, in the last fifteen to twenty years my career has been directed to interpreting power industry transmission and distribution systems developments and trends. This includes the objective of anticipating future system needs for the development and application of power systems equipment. I am a Fellow in the Institute of Electrical and Electronics Engineers. I am pleased to be of service to the Subcommittee to present some positions in behalf of both the Energy and Research & Development Committees of the IEEE.

Information presented in the DOE Fiscal Year 1982 Congressional Budget Request, Energy Supply Research and Development, Volume 3, Electric Energy Systems, is the basis of this overview on the programs and role of DOE in R&D. It should be a stimulus for questions from the Subcommittee. And, it should enhance their understanding for judgment in the decision-making process on the support of projects, some of which are proposed to be cut very materially.

It is my understanding that this portion of the FY 1982 budget on which I am commenting is subject to a proposed cut from $38.9-million to $9-million. I am not in a position to assess the amount of the budget cuts, nor to assess whether the final level is appropriate.

I do not oppose the funding of long-term, high risk projects. In fact, I agree with their support and indeed raise the question whether $38.9-million is an adequate R&D expense for the specifics proposed, in the light of the capital investment of the total energy business.

An extremely significant part of the EES program is power delivery, and related program elements. If we are to deal successfully with the energy problem we simply must start at one very important source, the generation of electric power. But, with equal priority, we must have the capability of delivering that electric energy through transmission and distribution lines -- and, it necessarily follows that we must be able to solve the problems that reliable power delivery requires.

Electric energy must be generated economically, reliably, safely, and in an environmentally acceptable way. And, it also must be transmitted so that it meets all of these same four criteria. In the early 1950's, 362,000 volts alternating current (A.C.) transmission became a commercial reality. Then, in the mid-60's, 550,000 volts; and in 1970, 800,000 volts followed. The number of miles of transmission in service today is 38,000 miles at 362,000; 20,000 miles at 550,000; and 2000 miles at 800,000 volts. Long distance power delivery from mine-mouth coal, hydro or nuclear plants located remotely from the urban load centers, can be delivered to the cities only because there is transmission technology at these voltage levels to provide the capability. In addition, transmission interconnects power plants, systems, and power pools or regions, and makes high reliability possible because of the support between plants, systems, etc. Likewise, the transmission makes possible emergency transfer of energy "by wire".

The industry is now considering UHV transmission systems at 1200 kV, i.e. 1,200,000 volts. The commercial use of such transmission is projected 1990 or beyond, very likely in the Pacific Northwest. Why should work be done on these developments now, and who should support it?

The question is not a parochial one that is of concern only to the United States. It is an international concern because of the commonality of the problems of energy generation and transmission. This point will be emphasized later in my statement. The answers require long-term, high risk R&D -- long-term from the viewpoint of time, e.g. ten years out; high risk because of high upfront costs. If the private sector is to support it then the payback must be assured in view of the uncertainties both for chance of success and limited commercial utilization. The payback is frequently predicted to be extended over an unacceptably long term for a healthy business.

The solutions to the problems do not simply derive from extrapolation of today's technology, but require R&D in areas where solutions beget new problems. For example, a 1200 kV line can carry 4000 kilowatts, the total output of one plant. What happens to the power system if the line fails, even momentarily? A 1200 kV utilizes right-of-way more efficiently. For example, it takes ten 345 kV circuits to carry the power of two 1200 kV circuits, but the 1200 kV only uses half the right-of-way. However, is it environmentally acceptable? Is a 1200 kV line safe for persons exposed to the electric field it creates? Or, is an underground line better, safer, but more costly? What problems would it create? For example, a line can be built and contained inside a 28-inch tube or sheath, filled with an insulating gas under pressure. With such an underground system, the 1200voltage creates no field effect exposure to humans or anything else around it.

The example of UHV is very apropos to focus on broader problems that the Subcommittee must consider. It and similar technologies identified in the EEI programs have international attention, e.g. USSR, Sweden, France, Germany, Italy, Japan, Canada, Brazil, Australia, to name a few. As I have previously stated, the U.S. need for UHV is 10 years out into the future. In an earlier day, the U.S. private sector could have supported the R&D, and did. This is as it should be. But, today the private sector can not support this R&D and realize the necessary return. One source of funding is an outside source such as DOE to provide support to R&D now so that technology is available when it is needed, and to develop and maintain U.S. human resources to compete in the international marketplace. If the U.S. does not sustain the technology now, it will be too late in 1982, or 3 or 4, much less 1990, when other countries have already long supported the R&D. In some other countries their economic system and government is designed to support and subsidize R&D in their private sector. This statement must not be construed as an argument on systems of government, but it points out a practical fact in the arena of international commerce.

DOE financial support is an alternative for the long-term, high risk projects. The U.S. must lead in technology through R&D in industry, and the universities. To lose position will only exacerbate the scenario of lower standards of excellence in U.S. science and engineering, enhance off-shore competition and eventual influx of non-U.S. products into the U.S. to the devastation of the U.S. economy. We can already see the effects today of this scenario in the short-term. Industry and the scientific community are attacking it to regain our competitive edge. The issue we are dealing with here is time. We must buy "research futures". Somehow, the seed money must be made available to reap the technical crops of the future.

Now, by what measure does DOE financial support, start and stop. The needs of people as perceived through industry and commerce inherently result in active scientific minds generating new ides. When we add wants and desires to the list, it is merely additional stimulus, -- fuel for the fires of technical imagination. We can always think up more things than we can do. Imagination focused on technology will expand demands beyond available resources both human and financial. The question that utlimately must be answered, is how do the answers, which obviously have a cost, get translated into a return on investment -- that also means a healthy status of growth and leadership for industry, commerce, universities, the scientific community, and least of all, quality of life for everyone.

The pattern that seems to have developed in DOE is to choose projects which fit the long-term, high risk category and then support them through demonstration projects, "fait accompli". Of course, the importance of the first step is obvious, that is, the selection of a project that is worthy of taking through the demonstration stage. Then, when the project has been successfully demonstrated, information should be available for dissemination so that the private sector can take over. Through this process the needs of the people as reflected by the particular development will be met, if it is indeed, needed. At that point the inconvertible law of supply and demand dictates the future destiny of the project. There then is no more need for government support. In fact, such support is detrimental to the free enterprise system and simply drains off human and financial resources into non-productive ventures.

A review of the FY 1982 budget suggests comments on projects that from our view essentially satisfy the foregoing criteria.

## SYSTEM ARCHITECTURE AND INTEGRATION

System Control and Development -- the projects generally covered in this category are long-term with potentially high benefits if successful for the improvement of power system reliability. The financial condition of the utility industry is such at the present time that because of insufficient capital, the only alternative is a Hobson's choice, reduced reliability -- hardly an acceptable alternative. The U.S. has unequivocally always had the highest power system reliability of any country in this world.

New Technology Integration -- includes photovoltaic, wind, solar thermal power, ocean thermal energy conversion (OTEC), solar heating and cooling (SH&C), fuel cell, battery, compressed air, underground pumped hydro, and cogeneration. The FY 1982 integration efforts will be primarily concerned with PV and wind. The issue is primarily one of cost/benefits in the choice of which one to concentrate effort, assuming the "demonstration project" philosophy is followed. For example, in the case of PV and wind, they utilize an undeniably appealing resource of nature, the question is, what is the realistic expected energy contribution relative to other energy potentials. One might make a better case for fuel cells as a long-term viable growth potential that the marketplace would more avidly support as a highly efficient energy resource for conversion to electrical energy. On the other hand, the benefits of storage might be argued as being of questionable commercialization because of the innefficiency of the input-output cycling of the basic energy resource.

Load Managment -- as the record indicates, the demonstrations have helped place this technology with existing private sector R&D so that the marketplace can decide its future, controversial though it may be in the eyes of pro and con arguments, state and other regulatory influences.

## POWER DELIVERY

Much of this program deals with the delivery of bulk power over transmission lines. A prominent utility executive once referred to them as "sinews of strength". They are just that, because in addition to hauling coal, water or nuclear by wire, they are critical in the support of generation facilities to a highly, reliable power system. My earlier remarks addressed the importance of this problem very directly.

Underground Transmission -- the inherently high cost ratio of underground to overhead makes this a long-term project in order to obtain significant economy. Progress has been made by reducing this cost from 20 to 1 to a potentially much more optimistic number. A very attractive project which requires a further injection of R&D is the new concept of flexible compressed gas insulated transmission lines. This technology has already been demonstrated in part to have favorable cost/benefits for application of underground in limited transmission corridors in cities or at power plants. The R&D emphasis is of greatest benefit at UHV voltage levels.

High Voltage Direct Current Technology (HVDC) -- This electric power transmission alternative is relatively new and deserves more space for comment than is feasible. Suffice it to say, however, from a technology viewpoint both in R&D and as a commercialized development, it is well advanced in the state-of-the-art as evidenced from U.S. domestic installations in service or planned. Swedish and German based companies along with one U.S. company have invested heavily in this technology. U.S. R&D funding has also supported the technology. One of the needed next steps is the development of an HVDC breaker. It could accelerate the use of HVDC networks, and is a long-term, low risk venture as to its chance of success.

Electric Field Effects (ELF) -- This is an issue of special interest because of the ambiguity whether or not the R&D is justified under the "demonstration" criterion. The compensating factor is that the subject has a morality issue so to speak, i.e. field effects could impact on people environmentally. Published literature and existing knowledge puts emphasis on a question to which we do not really know all of the answers. And, the subject also relates to UHV, a long-term problem on its own. R&D is necessary so that information can be discovered and documented, thus paving the way for voluntary compliance and standards by the private sector, a step that can reasonably be expected to happen.

High Voltage Alternating Technology (HVAC) -- previous comments earlier in this statement support an affirmative position on these efforts because of the projected usage of UHV ten years out into the future. Well established economic methods of generation and A.C. transmission make it an absolute necessity to advance A.C. technology in a proven, economical A.C. integrated network. Problems detailed in the program certainly deserve reinforcement of solutions for productivity in the electric energy A.C. transmission field.

I am honored to have the opportunity to present these views for the IEEE. As a concluding comment, the DOE can little afford to withdraw R&D support of the professional engineers and the private sector of this country, to regain and maintain our position of technological leadership. The best technology is the solid base for competitive leadership in the areas of international commerce.

Mr. **Wolpe**. Thank you very much, both of you, for very excellent testimony.

I would like to just elicit your reaction to the philosophical basis upon which the most recent proposals have been advanced through the Congress.

It is argued there is a very self-conscious attention to substantially reduce Federal funding for research and development, particularly in the energy area on the theory that the acceleration of investment incentives and the general improvement in the economy that is sought through the basic economic recovery plan will do the job, will do the job more efficiently and with less cost to the taxpayer and in a way that is more appropriate to the structure and theory, philosophy of our economic system.

What is your reaction to that general view?

Mr. **Thorn**. I will offer an initial comment, and that is I believe the incentives, as I indicated, that either are in place now or being contemplated, can have a very beneficial impact if one can get past the initial hurdle of deciding to go ahead with the project.

The point that I tried to make in my statement is that there can be a very considerable sum of money involved just in deciding to start a project, which in many cases will be very inhibiting, if not completely preclude the possibility of getting to a point where incentives can really play a part.

A project has to go to completion before those incentives can be claimed and made beneficial in the economic growth of the project, and I think that there is an earlier point where, on a selected basis, and we don't advocate this as a widespread thing, there are cases where Federal dollars can stimulate a project to a point where it can go ahead with local financing, and the couple of examples I have given, I think, bear that out.

Mr. **Lawrence**. I think that I tried to point out in some of the examples that in my statement, that there are projects which, for example, are 10 years away. They are just simply too far out, not only as regards their chance of success but whether or not there is going to be enough volume of usage for the private sector to take the risk. I think that Government funding can support a project, demonstrate it and make it an accomplished fact, and then let industry decide whether it can take over.

The issue we face is whether or not we can clarify the difference between the demonstration of a project and the commercialization of it.

There is one problem that I think the private sector has to face—Government, universities, and industry can all think of more ideas than there are resources to utilize, so of all the choices it has, it has to select a choice that is going to have a payback. Obviously, if it has a choice that it can see or that more than just one part of the private sector sees, is 10 years out, it is going to pick the choice with the short-term payback.

But, in the international arena, there are nonprivate sectors which are pouring funding in for some of these things, which we are not able to keep up by solely private funding. This is the point I am trying to make, I think there is a justification, for example, for the Department of Energy in the international arena.

Mr. **Wolpe**. It has been suggested that that is not a problem, that if the other countries are able to develop that technology so that we may purchase it here within the United States, why should the Government be concerned with the subsidization of research and development for our own industry?

Mr. **Lawrence**. Well, I think that eventually if you get into the state where the party from whom you are purchasing is the matter-of-course way of doing business, then you are dependent on them. I think that it is a high risk for our private sector or even for the Government to depend on somebody else outside the United States. My answer to that would be is that we need that independence.

Once we fall behind, we lose that independence.

Mr. **Thorn**. I support that statement entirely.

Mr. **Wolpe**. What would be your evaluation, in summary if you can, of the impact of the proposed budget cuts in the research and development area that are being proposed?

Mr. **Thorn**. That is a very, very general question. I can speak to it in Rocket Research's case in several projects that we have that could confront those budget cuts, and mainly Site, for example, in the case of the Bellingham program, what we believe to be a very dramatic nationwide impact, if that project goes to completion. It is the only one of its kind in being at the moment, and it is the type of project that is not apt to be funded locally, now or in the future.

I can't foresee a squeeze on the Nation to the point where at some time in the future it would be undertaken locally. It requires some Federal stimulation to move ahead. I think that is a good case in point of the type of thing that can be done beneficially with Federal funds, and I think that project is one that certainly requires the support.

Mr. **Wolpe**. Could you elaborate, if I may pursue that for just a moment; what specifically would be the private sector's concerns as they relate to the risks apparent in that project?

Mr. **Thorn**. In this case it is not their main business. It is not an energy recovery project that will benefit them in-plant in their production process. It is quite clear it is a peripheral part of their operations, and as such is not going to receive significant attention in the capital budgeting of the company.

Mr. **Wolpe**. The waste heat is simply there and the question is whether they are willing to make it available essentially?

Mr. **Thorn**. That is right. And in this case its quality is too low to be of use within the plant, and that is true of many, many industrial sites.

Mr. **Wolpe**. I take it the long-range projects would yield an enormous savings of dollars as well as energy to this country, much larger in some than the R. & D. element that would be involved?

Mr. **Thorn**. Yes; by many orders of magnitude, if implemented nationwide.

Mr. **Wolpe**. Dr. Lawrence, do you want to add to that?

Mr. **Lawrence**. Well, as he indicated, that was a fairly general question, and let me give it a general answer and point out one or two specifics which you may focus on.

I think that the problem that we have with energy is, as I said earlier, we have to produce it; we have coal, hydro, although the hydro is pretty well utilized in the United States, and nuclear. There is money being proposed for increases in nuclear. I am not absolutely positive of that statement.

But one thing that concerns me is whether or not there is an adequate effort being extended in these (EES) programs to support the delivery of a lot of power over a long distance, that is, the support of of the generating plants with necessary transmission.

Let me review briefly the area of control. There is a question of how reliably transmission performs the function not only of carrying the power from the source to where it is used, but does it support adjacent plants or adjacent pools or systems. If that transmission is not available, then it reduces the reliability of the power system.

There was another example that occurred to me that I can point to, and that is with respect to underground transmission. I mentioned that there was a 20-to-1 cost ratio of underground to overhead. That is discouraging, because, for example, if all of the electrical systems were placed underground (in the United States) it would raise the rates prohibitively. To just place 10 percent of them underground would raise the rates more than 10 percent. To place all of them underground would more than double the rates, which is not realistic economics.

Let me talk about an example in underground transmission, superconductivity. Let me give you some numbers as a base of reference.

An overhead transmission line can carry, depending on its voltage 500 megawatts. That is equivalent to a small generator, relatively speaking.

A UHV transmission can carry as high as 4,000 megawatts. A compressed gas insulation system could be used. It contains the voltage inside of a tube or a sheath and the electrical conductor no longer exposed to air. It can transmit 4,000 or 5,000 megawatts, which is equivalent to a whole plant, not just a single generator. Superconductivity would permit carrying power up to 10,000 megawatts.

Can you imagine all of that power being carried by a single line from one plant?

The point I want to make next is this: That superconductivity is a completely new change in technology, a change in economy of scale, to justify it economically you have to carry something like 15,000 or 20,000 megawatts. From the viewpoint of bringing that into the realm of practical usage, it is a very long term, very high risk in terms of whether or not it is going to be used.

That doesn't say it shouldn't be studied to know what its possibilities may be, but you tend to work on those things which will benefit you first.

Mr. WOLPE. Thank you.

I call upon the ranking minority member of the committee.

Mr. LUJAN. Thank you, Mr. Chairman.

Let me review a little bit with you the two projects that you spoke about, the chemical heat pump. It is in water and that heats it up. How do you distribute it, with a fan?

Mr. THORN. This harkens back to the old high school experiment of pouring sulfuric acid into water and it will yield heat.

That is a little oversimplified description of what happens in the unit. That heat is there and is recovered. There is also a heat of condensation from the manner in which the cycle works.

Mr. LUJAN. How do you get the heat into the building?

Mr. THORN. Oh, I am sorry; it would simply be provided through a radiation system or creation of hot water that is then distributed into a larger building or perhaps into an industrial process.

Mr. LUJAN. Then you pick it back up and distill out the water; then you reuse it?

Mr. THORN. Yes, sir.

Mr. LUJAN. The Bellingham District heating that you are talking about is taking the waste heat from a plant that exists already and piping it through other buildings, outlets, or whatever?

Mr. THORN. That is correct; we are making hot water at the plant, transmitting that hot water approximately 11 miles into an area near downtown where there is a storage facility involved and then distributing from that storage facility to individual user residences or small commercial users.

Mr. LUJAN. Well, why would not a private company, in this case, it is an aluminum company with the Bellingham District heating, and with the chemical heat pump, why wouldn't private industry want to take something like that on?

Let me give you an example. I live next door to a powerplant in Alexandria, probably, oh, 100 feet to where the boilers are in the building from where I live.

I have always wondered why they didn't take that excess heat out of there and sell it to the building owners. Why do we need Government funding for something like that when instead of buying oil or coal or natural gas you buy the steam?

Mr. THORN. That is a superlative idea. I might cite another project that I have not mentioned in the city of Tacoma, Wash., where we have just completed the feasibility study of a cogeneration plant. This is a renovation project of an existing steam boiler system that has been used for peaking electrical generation purposes in years past. It incurred some damage several years ago, and was shut down.

We have examined the possibility; it happens to sit in a fairly concentrated industrial site in northwest Tacoma, and in this case, there is a very nice heat sink in the industrial community whereby the excess energy from that plant, after making electricity, can be sent out for process use within that industry.

This is called cogeneration.

Mr. LUJAN. Well, my point is simply, why wouldn't you go ahead with the chemical heat pump because you will make some money when you perfect it and sell it to someone, and with this cogeneration system I can't understand why that is dependent on Federal funding because it seems like somebody could make some money out of it eventually, and that is the way the automobile came into being, and almost everything else.

Mr. THORN. In this case we are looking first at a very highly technical project, one that has been in process since 1976, and we are several years away yet from being at a stage where commercialization could jump off.

Mr. LUJAN. How much would it take to perfect this?

Mr. THORN. We have spent well over $1 million to date, $1.3 million is the figure, I believe, and it will require somewhere approaching three-quarters of a million dollars additional to carry it on to the stage where it could be commercialized.

Mr. LUJAN. That is not a lot of money when you are talking about private industry, large private industry.

Mr. THORN. No, sir, it is not; but it is quite a long process to introduce novelty or change into an industry or community or each of us where our habits are ingrained in a certain direction. There is a long developmental process of the market. It is not one that we are prepared to undertake on our own. Yet the energy savings from a national standpoint makes sense to me for the Federal Government to be involved and try to exploit that technology.

Mr. LUJAN. The whole utility industry started out by somebody coming up with how to make a powerplant and how to transmit it from one place to the other and how to hook it up without any Federal funding.

What is different about the ultra-high voltage lines? Sure, it is different from the technology that is needed, but what is different then when the utility industry had to come up with transmission lines of some kind.

What I am getting at is why the dependence on the Federal money when before there was an AEC or ERDA or DOE now, industry moved right on ahead with their needs and seemed to do very well. Maybe we have become too accustomed to help.

I am not arguing with you. I am exploring that. Maybe we have become too accustomed to Uncle Sam shelling out and industry not taking that responsibility, and they are the ones that are going to make some money out of it.

Mr. LAWRENCE. Well, the industry did in fact carry the original research and development for 345 kV, and 765, and this was put into commercialization in fact in 1970. The use of 765 kV, and the choice of a voltage is not entirely dependent upon a particular utility.

It may depend upon neighboring utilities, but the choice usually depends on how it relates to other parts of the system, and whatever voltages are in use.

The next higher level of voltage is a step in technology, which is not just an extrapolation of the previous technology or the projected need for it, either for carrying of large blocks of power from large powerplants or for energy interchange in an environment of conservation and reduced load growth.

The projections for this next step in voltage have slipped with time, but the technology is still required in order to assure that it will work, when its use is invoked. It is necessary to be able to answer the questions environmentally as well as whether or not a circuit can simply carry the current over the line at that voltage on a wide right-of-way.

I think in viewing foreign technology, they have the same problem, they have subsidized some of their private sector. There are competitive influences working, so one asks the question: Can we simply not do anything or should we look at new technology and have the answers ready if and when we need them?

**Mr. Lujan.** Wouldn't it be foolhardy of a utility to just let it go instead of continuing the research themselves?

**Mr. Lawrence.** The utility and the remaining private sector can no longer afford that research.

**Mr. Lujan.** Aren't we both facing that? Couldn't the point be made that Government can no longer afford it either?

**Mr. Lawrence.** I think that I would comment this way, and I don't mean to say other areas of expenditures are not productive, but——

**Mr. Lujan.** When the school lunch people, the military people, I can give you a whole list.

**Mr. Lawrence.** I understand, but I think it—R. & D.—has the chance of producing productive results in a field which is absolutely necessary to this country, and that is energy.

**Mr. Lujan.** Good point.

Thank you.

**Mr. Wolpe.** Mr. Forsythe?

**Mr. Forsythe.** Thank you, Mr. Chairman.

I would like to follow along my colleague, the ranking member here.

Mr. Thorn, in this Bellingham project you seem to imply that the value of this waste heat, so far as the cogenerated, the aluminum company, was not significant enough for them to really have an interest in moving foward.

**Mr. Thorn.** That is correct.

**Mr. Forsythe.** Now, to have enough value to make this whole deal——

**Mr. Thorn.** It is who it is of value to. In this case the aluminum plant came to make aluminum, not to make heat to meet the community needs.

**Mr. Forsythe.** We have seen so many examples of diversification of resource recovery already as a result of the very things that have been happening in this decade in terms of energy, and if this has got the payoff that you indicate, that value must be rather significant to that power company or aluminum company, rather.

What is that value in the competitive price of heating energy, either in process or in heating?

**Mr. Thorn.** I don't have an exact figure in my head; but as a relative comparison, we are looking at perhaps $1 million worth of energy sales at some point in the future, which is a bit indefinite in the way the project is put together, versus $400 million worth of sales of aluminum per year.

**Mr. Forsythe.** Aren't you really in a situation, it is a matter of market price, as prices go up, batteries have more potential; as oil goes up, nuclear begins to look even better and things like that, and the same thing goes, of course, to some of those other alternate sources, synfuels, tar sands.

Where do we go to find those energies? All of these things are related to what the market price is rather than exploration and development.

Isn't that really the kind of thing to be concerned about?

**Mr. Thorn.** Each of the alternative energies that are under development in one place or another in the country today will look better and better economically as time passes because of our forecasted continued rise in energy costs.

Mr. FORSYTHE. My constituents say that is moving awfully fast in terms of rising energy costs.

Mr. THORN. It is.

Mr. FORSYTHE. Dr. Lawrence, isn't perhaps looking more at R. & D. incentives worthwhile? And yes, we talk about the tax capital, the formation tax programs, and the depreciation and all of the various thing, investment tax credit and, of course, there is also the suggestion that there should be just an outright tax offset for research and development costs to really get private sector a better deal than this.

You don't think that these have the potential perhaps of making this transition again of bringing back the private sector that did develop, as you said, the most reliable distribution system the world has known, and with very little Federal dollars?

Mr. LAWRENCE. I believe that that is an alternative.

The alternative that I have been directing my comments to was the direct funding by the Department of Energy for projects which have the long term, high-term risk in light of the international commercialization. That is not the only alternative.

You have cited one other one which I think is an alternative.

Mr. FORSYTHE. Isn't there another major area, and that is not just Federal regulations but State and even local regulations that have inhibited new ideas in terms of the plant siting and all of these other factors that have made it more difficult for the private sector to move into these new areas?

Mr. LAWRENCE. This could get us into a very general area, but the regulatory positions, or let's say the results of regulatory actions, in my view, have created some of the problems to which we might address ourselves as to whether these are problems or opportunities.

Load management, for example, is reasonably well demonstrated at this point, and probably one of the driving forces for it is regulation.

Mr. FORSYTHE. Regulation rather than cost?

Mr. LAWRENCE. Well, I was going to continue. The cost advantage of load management depends upon the particular situation.

What we are basically doing in any electrical utility system is to change the peak cycle of the electric utilities' load curve—to level that curve out. It has a peak on it. It has a peak on it during the day and it has a peak on it which is an annual peak, and we try to use alternatives that would level that peak out.

The advantage of that is to be able to reduce the amount of capacity that is required in service and to use a more efficient generating source off of the peak. This levelizing of the load is a very delicate balance as to whether it is cost-effective. The savings have to pay for the cost of the load management equipment. In some cases this will be true.

Mr. FORSYTHE. I am from New Jersey, and we have a rather sophisticated pool that follows the loads, but I was in a power station within the last month where they have automatic load management. Actually, it is only one unit in that particular station.

Of course, it is most modern and to watch the rise and fall of the generation out of that one unit which was used to balance their whole system, by the way, and it was a more expensive unit to operate.

It was on oil; they were on coal at their other ones at this point, but they could balance their system by modulating that one unit, and it happened right there before your eyes without anybody putting a hand on it. That kind of thing is probably rather crude in what you are talking about in a nationwide sense, but is happening. Of course, I recognize there is one other major problem that has been mentioned.

Edison didn't have to worry about an SEC to float stock, and I think that is also something, and I am not recommending we do away with the SEC. I own a little bit of stock myself, but I think we perhaps it is in those areas of how we perhaps without appropriated dollars find the ways to make this work in the private sector and it is a traumatic change, and whether we can put it off I won't guarantee, but we must look for those kinds of things.

There may be some short-term ones that are just on that edge, as you say, Mr. Thorn, that would be tragic to not see them move foward at an early date, but you talk of nationwide figures. I suppose it is a long time down the road before anything could really make that work because we are such a dispersed nation in terms of population and everything else.

Mr. THORN. It is a very different problem, and it is when one gets to electrical energy.

Mr. LAWRENCE. May I comment, Mr. Forsythe?

It is interesting that each of those problems that get created for whatever reason, create solutions which beget more problems and provide more opportunities. Load management, for example, begets another problem, which is what we call distribution automation, and there is more R. & D. that could be done yet for further demonstrations. Whether that can be carried out by the private sector or not is very hard to predict at this point.

Mr. FORSYTHE. This morning one of the administration witnesses mentioned this problem of field effects of high voltage transmission and perhaps that seems to me the type of research that is bigger than any single utility, if you are looking at aboveground transmission at voltages that are above what we are using now.

Mr. LAWRENCE. We have a problem which again I would like to repeat, is not simply a technical problem or a biological problem, but it has a possible biological effect on people. It is also a perception problem, so that it becomes very complicated and it is very difficult for a single entity, a utility or anyone to create credibility in this area. This is an area in particular that provides information for setting a standard. I don't want to say we should set a standard. I think if they were set, then the private sector would comply to the standard in the voluntary system.

Mr. FORSYTHE. I think you set up a proposition that came out with the wrong answer, and that there are, many of these are perception problems, and so far as our nuclear situation right today in my view, that is, oh, 80, 90 percent really a perception problem so far as an awful lot of our people across this Nation are concerned, and it in effect practically stops nuclear advances.

I am not saying the light water reactor is the answer or the be-all. Perhaps, well, TMI, to be specific, has practically locked up our nuclear industry in this country, and it is a perception problem and it is one that I am afraid gets aggravated in this institution. I am a part of down here, and how we find our way through that one is real serious.

Perhaps it was through a newsletter, the outfit with TMI has just started in trying to get a low-key, really a public relations job of explaining the facts in hopefully a way that it will begin to be listened to. I recognize their problem. Again, it is going to be one of credibility as they do this.

Something that would help that credibility in saying those kinds of things are important things we have got to be concerned with.

Mr. **Thorn**. May I comment?

I think of Federal dollars and their spending needs in terms of national goals and objectives and impact. As a principal part of what I was trying to bring out by a specific example in the case of the Bellingham project, I think it is a consensus within the country that we have some energy problems, whether it is a crisis, or whatever, is yet to be demonstrated or yet to be fully defined; but when one can see an alternative of this sort of impact on a national scale, then that is an appropriate place to consider with some reasonable priority, assuming that energy is a national priority and there are specific goals within it, that is an appropriate place to put Federal dollars.

Mr. **Forsythe**. Of course, I read the first sentence in your second paragraph, and that has to do with your support of the shift in Federal spending control, and one of the problems, of course, we are facing on an hourly basis these days is everybody but me, and we are concerned and we can't pull the curtains down, turn the lights out and shut this country down. Finding our way through this is what we are looking for.

Thank you.

Thank you, Mr. Chairman.

Mr. **Wolpe**. Thank you.

Mr. Lawrence, is there any effort being made on the part of the electric utilities or the industry to investigate or have industry rather to investigate the viability of right-of-ways of high voltage DC transmission systems or high voltage AC transmission systems?

Mr. **Lawrence**. Did you say the right ways?

Mr. **Wolpe**. The right-of-ways.

Mr. **Lawrence**. Is there work being done by the private sector utilities to investigate right-of-ways?

Mr. **Wolpe**. For HVAC and HVDC?

Mr. **Lawrence**. Yes; I think there is work being done in the area for both of those.

Mr. **Wolpe**. Anything being done to coordinate that activity nationally, and is there a role for the Federal Government in that regard?

Mr. **Lawrence**. The right-of-way per se, of course, is a problem which is germane to the private utility itself and the area that it has to traverse.

There are regulations which impact on whether or not they can succeed in what they can obtain, crossing Government lands, for example, private lands. There are efforts, I believe, in EPRI to investigate the effects of high voltage DC and high voltage AC. And also as to how much high voltage transmmision is needed in a generic sense as opposed to a specific requirement for traversing a certain span of land.

Mr. **Wolpe.** If there is a dramatic cutback in the Federal support of research and development for power systems, would you anticipate a subsequent increase in intervention by foreign competition?

Mr. **Lawrence.** Well, I think that is one of those things whenever there is a slight dropping off somebody that is looking for a competitive edge will pick up on it.

Mr. **Wolpe.** Where will you anticipate the principal impact occurring?

Mr. **Lawrence.** UHV and DC, there are two foreign manufacturers who are ready to jump into supplying that technology into this country. That is not just in a research sense. Offhand, well, load management, I think and distribution automation, are others.

Those are the immediate ones. There is one other one, gas insulated substations, this is an extension of the compressed gas insulated transmission system using the same technology, but to enclose a substation within an enclosure that has sulfurheraflouride gas into it and there is foreign technology in that area also.

Mr. **Wolpe.** Mr. Thorn, the last question that I would have relates to the implications of the district heating project which your firm is engaged in.

Mr. **Thorn.** Yes.

Mr. **Wolpe.** You referred to the national potential in terms of energy gain or oil displacement.

Mr. **Thorn.** Yes.

Mr. **Wolpe.** As I think being equivalent to 10 percent of our energy consumption today or 25 percent of our oil imports.

What would be the capital outlay required to do the retrofitting or installation required to accomplish that on a nationwide basis?

Mr. **Thorn.** That is a very good question. I don't have the answer to it. It is one we can develop and submit.

However, recognizing it as an estimate, it is very difficult to assess, but within the constraints of the assumptions we can give a nomimal figure.

Mr. **Wolpe.** I am interested in exploring; it strikes me that we have not done a very good job of identifying those technological initiatives that would impact on the displacement of petroleum at the lowest possible cost within a given time frame.

What I would like is at least attempt is to get the kind of data that could be used on a comparative basis of alternative dollar investments, be they public or private sector, for the oil displacement, because then it seems to me we have a much greater fix on evaluating the potential of given technology and the relative merits or demerits of a Federal commitment.

I think that would be helpful. It is the case that Europe has been far ahead of the United States with respect to district heating systems of the sort that you envision?

Mr. **Thorn.** That is correct.

Mr. **Wolpe.** Is that primarily because of the differential cost of energy in Europe?

Mr. THORN. It is my belief——

Mr. WOLPE. Are there any other institutional barriers that have made that adaptation more difficult here than in European cases where they have developed it more fully?

Mr. THORN. I don't believe that there are. We saw a techonology departure some years back where under the pressure of rising conventional energy costs, Europeans foresaw the development of hot water systems which would allow a longer reach with the distribution of the energy than conventional distribution systems.

An example is that one can reach upwards of 20 miles with hot water whereas the reach on a steam system is on the order of 2 miles.

Mr. WOLPE. What are some specific examples of hot water systems already in place in Europe?

Mr. THORN. Again I would like to submit that separately. I can't tell you, off the top of my head. Almost every major European city has systems in place and it would be a matter of selecting out some very good examples, cities such as Stockholm, for example.

Mr. WOLPE. If you could also indicate the capital requirements for the adaptation and some indication of what that has meant in terms of energy consumption.

Mr. THORN. I am not sure that data is available.

Mr. WOLPE. If it is, that would be most helpful.

[The information follows:]

[illegible]
[illegible] WASHINGTON 98052
(206) 885-[illegible] TWX 910 449 2861

**ROCKET RESEARCH COMPANY**
ROCKCOR

April 10, 1981
Ref. No. 3200-81-107

The Honorable Marilyn L. Bouguard
U.S. House of Representatives
Chairman, Subcommittee on Energy
Research and Production
2334 Rayburn House Office Building
Washington, D.C. 20515

Dear Representative Bouguard:

At the March 16, 1981 hearing of the Subcommittee on Energy Research and Production chaired by Representative Wolpe, I presented a statement on behalf of Rocket Research Company concerning Federal Government involvement in the energy research and development process. At the conclusion, it was requested that I provide answers to the two following questions:

1. What is the capital investment required if the technology utilized in the Bellingham, Washington, district heating program (i.e., use of industrial reject heat coupled to thermal storage as the energy source) were fully implemented nationwide? The associated energy savings achievable with present technology is estimated at 5 to 8 quads annually which, in turn, represents approximately 10 percent of our national energy demand. In terms of oil and gas displacement in the residential space and water heating sector, this represents between 2 and 3 million barrels of oil per day or approximately 25% of our nation's oil imports.

2. What cities in Europe (or elsewhere) have district heating systems?

In response to the first question, Rocket Research Company estimates that the capital investment to achieve the potential annual energy savings of 5 to 8 quads, including user equipment costs, is $400 to $600 billion ($1980) based on the estimated costs of the Bellingham system.

This yields a capacity cost of $800 per kilowatt which compares very favorably, for example, to new central electrical generating capacity which typically exceeds $1,000 per kilowatt. Even with this comparison, however, district heating systems are considered capital intensive. The significant economic advantage of this technology is its lower delivered energy cost. Rocket Research Company studies show that first-year delivered energy costs with district heating are slightly lower than existing energy sources and that future year costs are significantly lower. This results from the fact that the cost of energy from existing sources is fuel-cost intensive and quite sensitive to inflation/escalation, whereas a district heating system using an otherwise reject heat source and energy storage has very low "fuel" cost which, in turn, causes the delivered energy cost to be primarily dependent upon the fixed capital investment. Thus, an inflation hedge is provided and energy consumers benefit substantially from such an investment. Additionally, large quantities of oil and natural gas usage are offset with an attendant accrual of numerous benefits.

Rocket Research Company believes, per my statement to the Subcommittee, that selective Federal funding to stimulate the application of this technology can have a very beneficial impact on the lead time required for its implementation by reducing the real or perceived risks of individual projects such as the one in Bellingham, Washington.

In answer to the request for a list of cities that have district heating systems, attached hereto you will find a partial listing of European and other district heating sites. A principal list of such systems operated by Compagnie Generale de Chauffe (CGC) in France is included. CGC is a joint venture partner in Rocket Research Company's sister division, Trans Energy Systems, Inc. If you or other members of the Subcommittee wish to inspect any of the CGC systems and discuss its operation, we will be happy to schedule a visit.

Rocket Research Company appreciates the opportunity afforded to address the subcommittee with our thoughts on this matter. If we can be of further service, please advise.

Very truly yours,

ROCKET RESEARCH COMPANY

William F. Thorn

William F. Thorn
Director, Energy R&D

WFT:bam

Enclosure

cc: Mr. Duane W. Lundahl
Rocket Research Company
5454 Wisconsin Avenue, Suite 1455
Washington, D.C. 20015

Mr. Doug Huxtable
Trans Energy Systems, Inc.
14711 NE 29th Place, Suite 101
Bellevue, WA 98007

Dr. James Swisher - DOE

# ATTACHMENT A

# PARTIAL LISTING OF HOT WATER DISTRICT HEATING SYSTEMS AROUND THE WORLD

## TRANS ENERGY SYSTEMS, INC. (TES)

TES is a joint venture of ROCKCOR, Inc., and Compagnie Generale de Chauffe (CGC) of Lille, France. (See organization chart illustrating relationship and functions, included with enclosures.) Trans Energy Systems draws from CGC European experience, which includes the provision of heating, air conditioning, and energy conservation services to 600,000 collective dwellings, 2,200 educational establishments, 900 public buildings, 650 health establishments, 65 functioning district heating systems and millions of square feet of commercial space. Additional experience has been gained through the installation of several operating refuse treatment facilities (cogeneration systems), five geothermal installations and two solar energy district heating systems.

One example of a proven alternative-resource-fired district heating system is in Nice, France. This system, which was installed by CGC, produces 8.5 MW of cogenerated electricity, 110,000 pounds of steam per hour for nearby hospitals, and hot water district heating for 6,000 apartments and other commercial facilities. Information on selected district heating systems designed and operated by CGC and specific information on geothermally heated district heating systems is contained in the attached pages.

## MAJOR DISTRICT HEATING SCHEMES OPERATED BY COMPAGNIE GENERALE DE CHAUFFE AND ITS SUBSIDIARIES

| LOCATION | NUMBER OF APTS. | PEAK DEMAND Therms/Hr. | TYPE OF FUEL | SUPPLY WATER TEMP. | ACS | DESIGN BY CGC | OPERATED BY CGC |
|---|---|---|---|---|---|---|---|
| AIX EN PROVENCE | 4,600 | 48,500 | Oil | 180°C | 15 | X | X |
| AMIENS-ETOUVIE | 2,600 | 24,000 | Oil | 180°C | 12 |  | X |
| BURES-ORSAY | 7,115 | 91,900 | Oil | 190°C | 10 |  | X |
| CALAIS | 2,940 | 30,500 | Oil | 180°C | 12 | X | X |
| EVREUX | 3,530 | 44,700 | Oil | 190°C | 15 | X | X |
| MELUN | 2,500 | 26,420 | Fuel & Geothermal | 110°C | 10 | X | X |
| METZ-BORNY | 4,653 | 60,200 | Coal & Oil | 180°C | 13 | X | X |
| MONTEREAU | 3,700 | 40,000 | Coal & Oil | 190°C | 12 |  | X |
| NEMOURS | 1,940 | 22,000 | Oil | 190°C | 10 |  | X |
| NICE | 4,270 | 40,200 | Oil & Incinerate | Steam @ 110°C | 5 | X | X |
| NIMES | 5,060 | 68,990 | Coal & Oil | 220°C | 10 |  | X |
| RENNES | 4,805 | 80,260 | Oil & Incinerate | 180°C | 15 |  | X |
| ROUBAIX | 3,075 | 36,180 | Oil | 110°C | 12 | X | X |
| WATTRELOS | 2,150 | 25,880 | Oil | 110°C | 11 | X | X |
| RUNGIS | - | 135,000 | Oil | 190°C | 11 |  | X |
| STRASBOURG-ESPLANADE | 4,400 | 70,000 | Coal & Oil | 190°C | 11 |  | X |
| VANDOEUVRE Les NANCY | 6,760 | 86,200 | Coal & Oil | 190°C | 13 | X | X |
| SAINT LOUIS MONTBELIARD | 2,900 | 36,300 | Oil & Gas | 180°C | 8 | X | X |
| BOURGES | 5,720 | 50,200 | Coal & Oil | 180°C |  | X |  |
| RILLIEUX CREPIEUX | 3,600 | 48,000 | Oil | 180°C | 12 |  | X |
| CHERBOURG | 2,950 | 25,800 | Oil | 110°C | 14 | X | X |
| ANNAPES (Cite Scientifique) | 3,280 | 26,525 | Oil & Gas & Coal | 190°C | 14 | X | X |
| LILLE ST. SAUVEUR | 1,402 | 36,000 | Oil & Gas | 180°C | 15 | X | X |
| LILLE EST | 1,380 | 25,190 | Oil | 110°C | 6 | X | X |
| ROUEN LES SAPINS | 7,370 | 62,000 | Oil | 180°C | 16 | X | X |
| SOISSONS | 2,433 | 27,500 | Oil | 110°C | 11 | X | X |
| MONS EN BAROEUL | 5,300 | 56,200 | Oil | 190°C | 10 |  | X |
| LAVAL | 2,290 | 31,300 | Oil | 110°C | 8 | X | X |
| SANNOIS | 3,000 | 25,000 | Oil | 110°C | 4 | X | X |

| ESTABLISHMENT | PEAK UTILIZATION MW | COMBUSTION | | CONSUMPTION 1979 - 1980 COAL ONLY (TONS) | PRODUCTION |
|---|---|---|---|---|---|
| | | QUALITY | LHV BTU/LB | | |
| Villeneuve d-Ascq (University Campus) | COAL - 11.8MW<br>OIL - 6.2<br>GAS - 17.4 | Stoker Coal - Lorraine | 12,780 | 4,960 | Hot Water 356°F |
| BETHUNE - Z.U.P. | COAL - 9.3<br>OIL - 13.9 | Stoker Coal - Lorraine | 12,780 | 2,425 | Hot Water 356°F |
| LENS - Z.U.P. | COAL - 8.1<br>- 20.3<br>- 13.9 | Slack Coal - Lorraine | 12,780 | 8,270 | Hot Water 356°F |
| LAXOU - HARDEVAL | COAL - 3.5 | Slack-Lorraine | 11,160 | 2,870 | Hot Water 230°F |
| LAXOU - HOSPITAL | COAL - 5.3 | Slack-Lorraine | 11,160 | 6,610 | Steam @ 147 psig |
| MONTBELIARD - HOSPITAL | COAL - 4.0<br>- 2.3 | Slack Coal - Lorraine | 11,160 | 4,400 | Hot Water 230°F<br>Steam @ 176 psig |
| MARSEILLE - HOSPITAL | COAL - 13.9 | Provence | 10,440 | 13,230 | Hot Water 356°F |
| NIMES - Z.U.P. | COAL - 29.0<br>OIL - 11.6<br>- 40.6<br>- 29.0 | Stoker Coal - Provence | 13,140 | 7,720 | Hot Water 356°F |
| VANDOEUVRE - Z.U.P. | COAL - 23.2<br>OIL - 11.6<br>- 34.8 | Stoker Coal - Lorraine | 12,780 | 23,000 | Hot Water 356°F |
| BOURGES C.U. | COAL - 8.7<br>OIL - 11.6<br>- 20.3 | Central France | 10,710 | 18,730 | Hot Water 356°F |
| STRASBOURG - Z.U.P. | COAL - 24.3<br>OIL - 40.6 | Stoker Coal - Lorraine | 12,780 | 8.050 | Hot Water 356°F |
| ST. DIE - Z.U.P. | COAL - 6.4<br>OIL - 0.3 | Slack Coal - Lorraine | 11,160 | 3,970 | Hot Water 230°F |
| MIRECOURT - HOSPITAL | COAL - 4.2 | Stoker Coal - Lorraine | 12,780 | 3,640 | Steam @ 235 psig |
| MONTEREAU | COAL - 14.5<br>- 29.0<br>OIL - 4.9 | Stoker Coal - Lorraine | 12,780 | 12,570 | Hot Water 356°F |
| METZ - Z.U.P. | COAL - 9.3<br>- 29.0 | Stoker Coal - Lorraine | 12,780 | 12,120 | Hot Water 356°F |
| VITRY LE FRANCOIS - Z.U.P. | COAL - 3.9<br>- 4.1 | Slack Coal - Lorraine | 11,160 | 3,640 | Hot Water 230°F |

# OPERATION OF A GEOTHERMAL SCHEME IN AQUITAINE, FRANCE

## MONT-DE-MARSAN

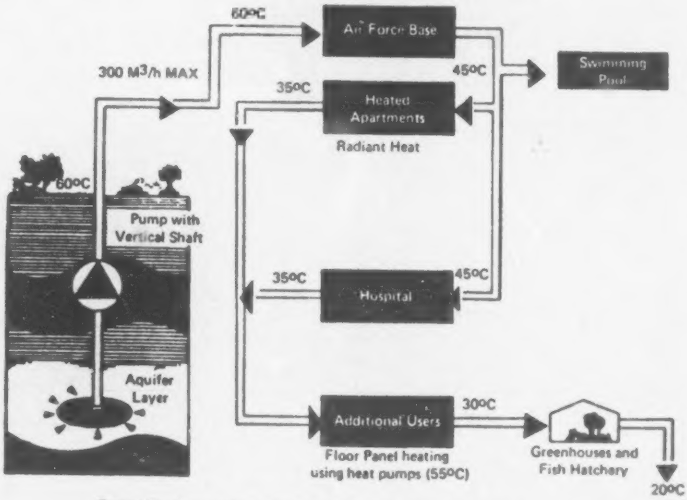
In 1976, the Groupement Elf-Compagnie Generale de Chauffe (COGETEC) constructed a geothermal facility in Mont de Marsan, by drilling to an aquifer layer at 1,850 meters providing 60°C hot water without reinjection.

A fiber glass network serves the following: an Air Force Base, the Helen Boucher Apartments (384 floor panel heated apartments converted in 1977), and the entire heat load for the St. Anne Hospital. Various other users are provided energy via coupled heat pumps. In order to utilize the maximum energy available, the network also provides heat to local greenhouses and a fish hatchery.

### MAIN CHARACTERISTICS

| | | | |
|---|---|---|---|
| – Geothermal water temperature | 60°C | – Energy conservation: | |
| – Output rate | 100/300m³h. | ● in 1978 | 1,300 tons of fuel |
| – Heat load connection in final stage | 18 MW approx. | ● completion of operation | 3,300 tons of fuel<br>(oil equivalent) |

VILLE DE MONT DE MARSAN
operation of geothermal energy scheme
for heat generation in existing buildings


60°C
Air Force Base
300 M3/h MAX
45°C
Swimming Pool
35°C
Heated Apartments
Radiant Heat
60°C
Pump with Vertical Shaft
35°C
Hospital
45°C
Aquifer Layer
Additional Users
30°C
Floor Panel heating using heat pumps (55°C)
Greenhouses and Fish Hatchery
20°C

French Geothermal Committee provided partial financing for this installation.

TRANS ENERGY SYSTEMS, INC. BELLEVUE, WASHINGTON U.S.A.

# OPERATION OF A GEOTHERMAL SCHEME

## SOCIETE THERMIQUE DE MELUN L'ALMONT (S.T.H.A.L.)

Since 1976, the Compagnie Generale de Chauffe Group has been operating, through its Subsidiary Company, STHAL, a joint-venture with Enerchauf, the first French geothermal installation in Melun L'Almont. A geothermal drilling allows the use of the Dogger layer at a depth of 1,800 meters through a doublet of deviated wells.

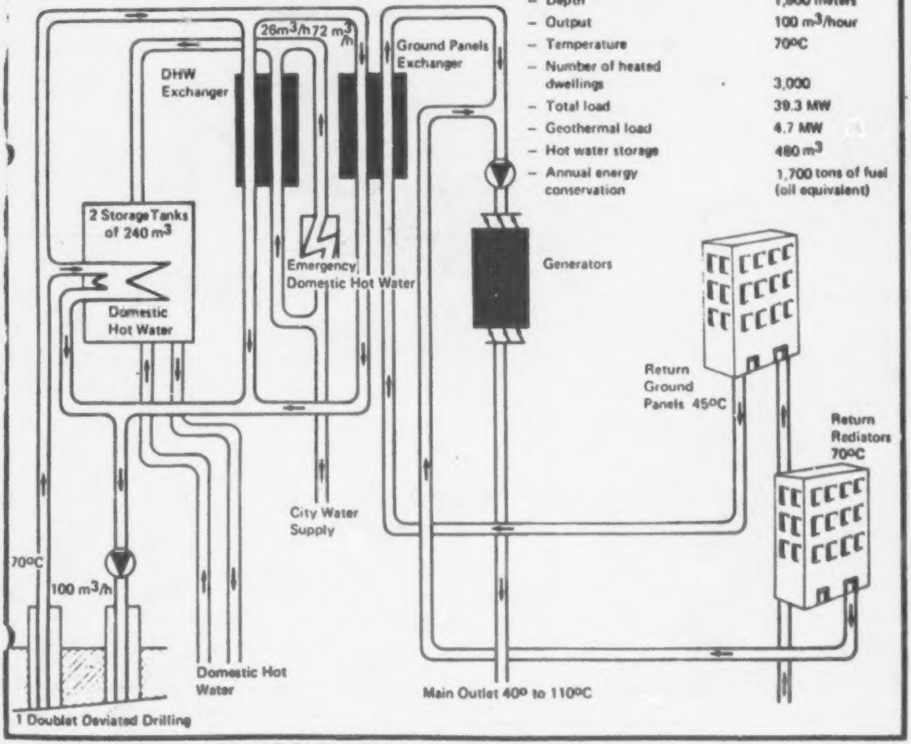
The geothermal energy is sufficient to produce the whole of the domestic hot water necessary for the 3,000 dwellings planned for the final stage (2,700 dwellings are connected in 1978). It contributes also to the generation of heat for heating requirements of the scheme the necessary balance of which is supplied by a traditional boilerhouse.

Part of the distribution mains supplies dwellings heated by means of radiators, the others being heated by means of floor panels. The geothermal fluid allows the re-heating of the return water of the floor panels circuit.

**MAIN CHARACTERISTICS**

| | |
|---|---|
| – Deviated doublet | |
| – Depth | 1,800 meters |
| – Output | 100 $m^3$/hour |
| – Temperature | 70°C |
| – Number of heated dwellings | 3,000 |
| – Total load | 39.3 MW |
| – Geothermal load | 4.7 MW |
| – Hot water storage | 480 $m^3$ |
| – Annual energy conservation | 1,700 tons of fuel (oil equivalent) |

BASIC DIAGRAM



26m³/h 72 m³/h
Ground Panels Exchanger
DHW Exchanger
2 Storage Tanks of 240 m³
Domestic Hot Water
Emergency Domestic Hot Water
Generators
Return Ground Panels 45°C
Return Radiators 70°C
City Water Supply
70°C
100 m³/h
Domestic Hot Water
Main Outlet 40° to 110°C
1 Doublet Deviated Drilling

TRANS ENERGY SYSTEMS, INC. BELLEVUE, WASHINGTON U.S.A.

# OPERATION OF A GEOTHERMAL SCHEME IN

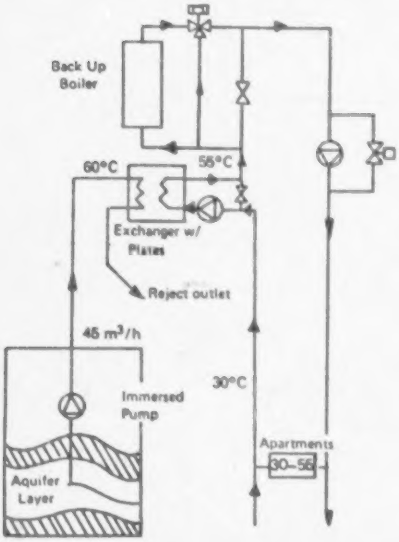
## ZAC DE BLAGNAC-RITOURET

In 1976, L'Union Technique Elf-Generale de Chauffe, under contract to ZAC de Blagnac-Ritouret built a geothermal facility in the Toulouse Region utilizing a single well 1,600 meters deep.

When the "ZAC" is completed, this geothermal facility will supply the total energy for domestic hot water and a part of the energy for the heating requirements for 2,000 dwellings. The peak loads are supplied by a traditional boiler plant.

The heating installation for ZAC has been designed to permit the usage of low temperature water (55/30° with - 5°C external temperatures).

MAIN SCHEMATIC


Back Up
Boiler
60°C
55°C
Exchanger w/
Plates
Reject outlet
45 m³/h
Immersed
Pump
30°C
Apartments
30–55
Aquifer
Layer

MAIN CHARACTERISTICS

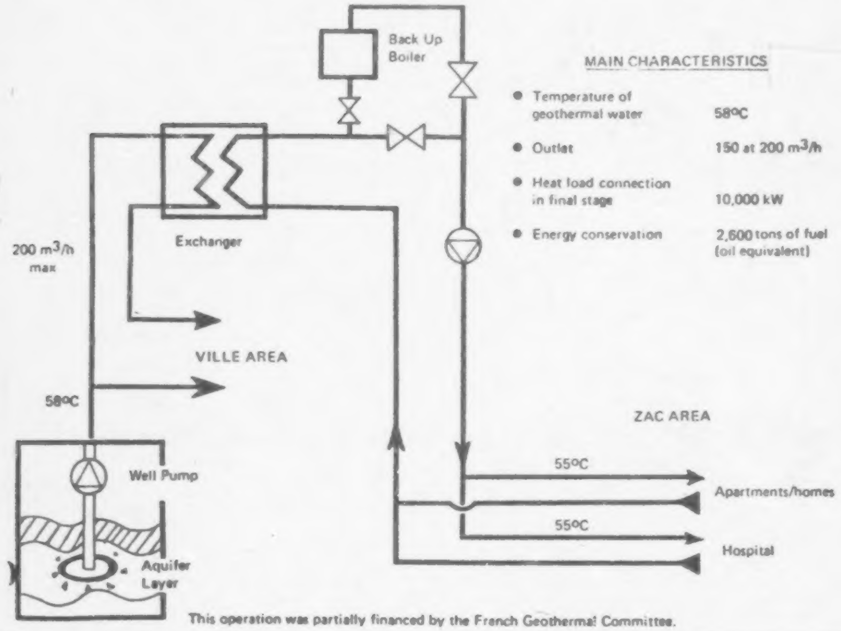
| | |
|---|---|
| – Main Well | |
| – Depth | 1,600 meters |
| – Outlet | 45 m³/h |
| – Temperature | 60°C |
| – Number of heated apartments | 2,000 |
| – Total generation | 12 MW |
| – Geothermal generation | 1,3 MW |
| – Annual energy savings | 1,000 tons of fuel |

# OPERATION OF A GEOTHERMAL SCHEME FROM A HOT SPRING RESORT IN

## DAX

Designed by Compagnie Generale de Chauffe in conjunction with the BRGM Geothermal Division, a geothermal operation was constructed in 1979 with the financial assistance of the City of DAX. Union Technique Elf - Generale de Chauffe was responsible for the overall geothermal heat distribution plan to provide service to the City's ZAC des Bords de l'Adour area.

The geothermal network provides domestic hot water heating to many apartments, school, shops and a 500 bed hospital. Furthermore, the geothermal water is used by a local utility, "Regie Municipale," through the existing domestic hot water network of the city.


Back Up Boiler
Exchanger
200 m3/h max
VILLE AREA
58°C
Well Pump
Aquifer Layer
ZAC AREA
55°C
Apartments/homes
55°C
Hospital

MAIN CHARACTERISTICS

| | |
|---|---|
| Temperature of geothermal water | 58°C |
| Outlet | 150 at 200 $m^3/h$ |
| Heat load connection in final stage | 10,000 kW |
| Energy conservation | 2,600 tons of fuel (oil equivalent) |

This operation was partially financed by the French Geothermal Committee.

TRANS ENERGY SYSTEMS, INC. BELLEVUE, WASHINGTON U.S.A.

| Country | Location | System Heat Capacity ($MW_{th}$) | Years in Service | Supply Temp (°F) |
|---|---|---|---|---|
| West Germany | Berlin | 1,924 | 55 | 131 to 230 |
| | Dusseldorf | 580 | 15 | 230 to 266 |
| | Bielefeld | 440 | 24 | 158 to 266 |
| Sweden | Gothenburg | 1,306 | 27 | 185 to 248 |
| | Uppsala | 791 | 18 | 240 |
| | Stockholm | 1,544 | 26 | 176 to 248 |
| Italy | Brescia | 182 | 7 | 302 |
| Netherlands | Amsterdam | Unknown | 12 | 356 |
| Japan | Sapporo | 198 | 8 | 419 |
| | Osaka | 50 | 9 | 356 |
| | Chiba City | 23 | 5 | 230 to 266 |
| | Fukuoka | 23 (hot)<br>17 (chill) | 6 | 248 (hot)<br>45 (chill) |
| | Tokyo | 11* | 6 | 176 |
| | Hokkaido | 7.5 | 5 | 248 |
| Russia (including Siberia) | Over 1,000 systems, total capacity approximately 500,000 $MW_{th}$. Usual supply temp is 300°C with long transmission distances (25 to 40 miles). | | | |

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* 157 total proposed - provides heat and chill.

Mr. WOLPE. I have no further questions.

I want to thank both of you for your testimony this morning. I think it has really been very consistently presented and very helpful in developing the implications of the budget that is before us.

Thank you, again.

Mr. THORN. Thank you.

Mr. LAWRENCE. Thank you, Mr. Chairman.

Mr. WOLPE. The subcommittee is adjourned.

[Whereupon, at 11:45 a.m. the Subcommittee on Energy Research and Production of the Committee on Science and Technology adjourned.]

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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## TUESDAY, MARCH 17, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met at 1:35 p.m. in room 2203 of the Rayburn House Office Building; Hon. Marilyn Lloyd Bouquard presiding.

Present: Representatives Bouquard, Volkmer, Wolpe, Ottinger, Lowry, Lujan, and Forsythe.

Staff present: Dr. John V. Dugan, science consultant; Gordon Chipman, technical consultant; and Lee Wallace, minority counsel.

Mrs. Bouquard. The hearing will come to order. Today we will hear from the Department of Energy on two very critical nuclear programs, the liquid metal fast breeder reactor and the nuclear fuel cycle R. & D.

The outside witnesses we heard from in the past several weeks generally agreed on two major directions in these nuclear programs. First, there was a strong consensus to proceed with Clinch River breeder reactor project, a technology demonstration facility which the Committee has funded for the past four years in the face of strong opposition from the previous Administration.

Second, we received a variety of testimony attesting to strong support for the use of the Barnwell nuclear fuels plant in South Carolina as the key facility for the United States to exercise the option of reprocessing nuclear fuels. I expect the Department will be able to tell us a little more today about its plans. As I understand it, the Department will request funds for Clinch River but not Barnwell.

As all the subcommittee members know, we're under very strong budgetary pressures and about to embark on an unprecedented application of the reconciliation provisions of the Budget Act. I have been particularly interested in keeping the overall subcommittee authorization budget down toward the Reagan requests, and the Republican members are supportive of this goal as well.

There are some programs from which I have suggested ceilings below the DOE request for fiscal year 1982, which is an indication of the kind of hard choices that we must make next week at markup.

I am looking forward to working with the DOE this year on nuclear R. & D. rather than having to combat the administration. So gentlemen, welcome. We do expect to hear some good news this afternoon. The first witness this afternoon is Mr. Mahlon Gates, who is Acting Assistant Secretary for Nuclear Energy, and he is accompanied by members of his staff, Dr. Thomas Dillon, Mr. Robert Staker, Mr. Lochlin Caffey, and Mr. Jerry Griffith.

Mr. Gates, you may proceed.

Mr. GATES. Madame Chairman, it is again a pleasure to appear before the committee at this time to discuss the breeder reactor and the nuclear fuel cycle. You have identified my colleagues who accompany me today. On my immediate right is the Deputy Assistant Secretary for nuclear reactor programs, Dr. Tom Dillon, who, with your approval, will make our presentation today.

Mrs. BOUQUARD. Please proceed, Dr. Dillon.

## STATEMENT OF DR. THOMAS A. DILLON, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR REACTOR PROGRAMS, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY MAHLON GATES, ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY; ROBERT STAKER, DIRECTOR, OFFICE OF REACTOR RESEARCH AND TECHNOLOGY; LOCHLIN CAFFEY, DIRECTOR, CLINCH RIVER BREEDER REACTOR PLANT PROJECT OFFICE; AND JERRY GRIFFITH, DIRECTOR, OFFICE OF LIGHT WATER REACTORS

Dr. DILLON. Thank you, Madame Chairman. It's a pleasure to appear before you to discuss the Department of Energy's nuclear reactor research and technology program. I'm accompanied today by Mr. Robert Staker, who is the Director of the Office of Reactor Research and Technology, to my immediate right; Mr. Lochlin Caffey, Director of the Clinch River Breeder Reactor Project Office, on General Gates' left; and Mr. Jerry Griffith on my far right, who is the Director of the Office of Light Water Reactors and responsible for the fuel cycle programs.

The budget request contains four major program parts: The Clinch River Breeder Reactor Project, the Breeder Reactor Studies—that's a conceptual design study—the Liquid Metal Fast Breeder Reactor Base Program, and Fuel Cycle Research and Development. A general discussion of program objectives, organizations, and accomplishments is contained in my formal submittal for the record.

I would like to devote a few minutes to the strategy underlying our breeder program. I will then be happy to answer any questions you may have.

### PROGRAM STRATEGY

Nuclear is one of the two principal energy sources for meeting the U.S. electrical energy needs over the coming decades. It is now and will continue in the future to play a major role in reducing our dependence on oil for electric generation. In addition, I believe that nuclear power will be absolutely essential to support increases in economic growth.

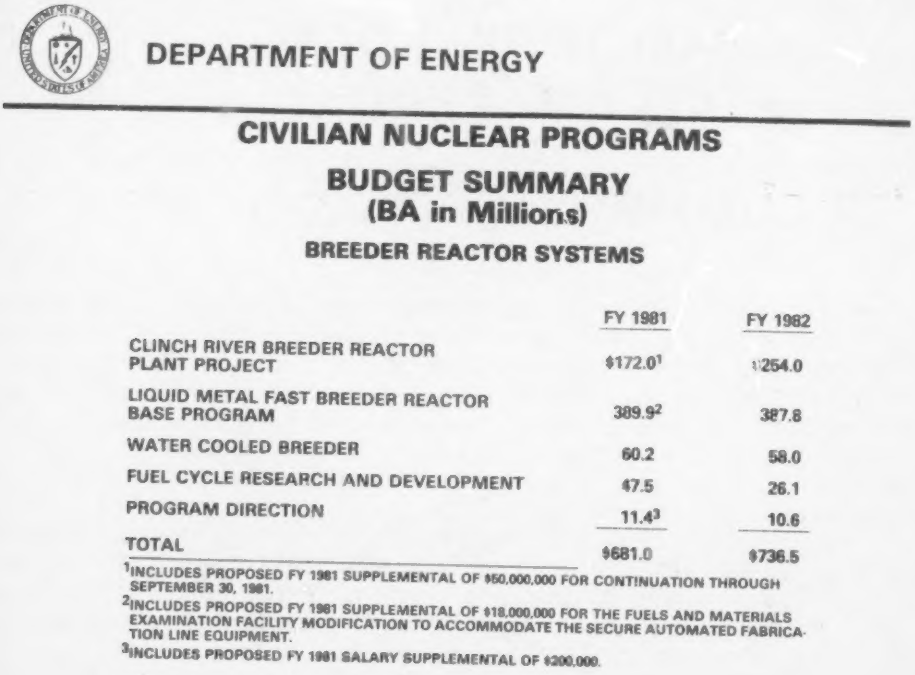
The breeder reactor, an essentially inexhaustible source of electrical energy, is a key element of an overall domestic energy strategy to achieve a safe domestic supply of economical energy to support a healthy economy. The breeder is the logical next step in the evolution of nuclear power development. As the natural uranium resources base becomes committed, breeders will increasingly become the choice for new capacity. The purpose of our breeder program is to conduct the necessary research, development, and demonstration activities to insure that a breeder reactor is available to this country.

Timing of breeder introduction and long-term commercial prospects are uncertain. While numerous studies have undertaken to answer the question, "When is the breeder needed," it will be the marketplace that will determine the commercialization of the breeder. Some studies show that breeders will be economically competitive with light water reactors around 2010, while others indicate a range in the 2020-2030 time period. In any event, given the time required to conduct the necessary research and development projects associated with such a complex technology, we must begin our scale-up engineering activities now.

Madame Chairman, the remainder of my statement is quite lengthy. I would like to request your permission to submit it for the record and to proceed with an overview with the use of viewgraphs.

Mrs. BOUQUARD. Without objection, it will be made a part of the record of this hearing.

Dr. DILLON. Viewgraph 1 shows the fiscal 1982 budget, and it indicates that there is significant initiative proposed both in the fiscal year 1982 budget and in fiscal year 1981 supplementals for the breeder reactor.



DEPARTMENT OF ENERGY

## CIVILIAN NUCLEAR PROGRAMS

## BUDGET SUMMARY
(BA in Millions)

### BREEDER REACTOR SYSTEMS

| | FY 1981 | FY 1982 |
|---|---|---|
| CLINCH RIVER BREEDER REACTOR PLANT PROJECT | $172.0[1] | $254.0 |
| LIQUID METAL FAST BREEDER REACTOR BASE PROGRAM | 389.9[2] | 387.8 |
| WATER COOLED BREEDER | 60.2 | 58.0 |
| FUEL CYCLE RESEARCH AND DEVELOPMENT | 47.5 | 26.1 |
| PROGRAM DIRECTION | 11.4[3] | 10.6 |
| TOTAL | $681.0 | $736.5 |

[1] INCLUDES PROPOSED FY 1981 SUPPLEMENTAL OF $50,000,000 FOR CONTINUATION THROUGH SEPTEMBER 30, 1981.

[2] INCLUDES PROPOSED FY 1981 SUPPLEMENTAL OF $18,000,000 FOR THE FUELS AND MATERIALS EXAMINATION FACILITY MODIFICATION TO ACCOMMODATE THE SECURE AUTOMATED FABRICATION LINE EQUIPMENT.

[3] INCLUDES PROPOSED FY 1981 SALARY SUPPLEMENTAL OF $200,000.

VIEWGRAPH 1

Dr. DILLON. As we've said, our primary goal is to provide the United States with a technological/industrial base that will allow for the timely deployment of the LMFBR system in the commercial sector. The breeder systems, as this committee well knows, provides for a sixtyfold increase in the energy which can be extracted from our uranium resources. Just given resources that have already been identified, that's sufficient to meet all of our electrical energy requirements for thousands of years. This is a virtually inexhaustible source for domestic energy, makes the breeder program unique, and is responsible for its high priority.

Access to breeder technology has to be fundamental to our long-term economic and national security. As breeders are deployed on a widespread basis, they will represent a potential market of multi-hundred-billion-dollar dimensions; it's imperative our own domestic suppliers have access to such a market.

## BREEDER PHASES

- REPROCESSING
- TECHNOLOGY AND ENGINEERING
  - CRBR
  - LDP
  - BASE TECHNOLOGY
  - FUEL CYCLE R&D
- COMMERCIAL DEVELOPMENT

VIEWGRAPH 2

Dr. DILLON. Viewgraph 2 shows the three key phases upon which achievement of our goals for breeder technology will rest. They are: Reprocessing of breeder technology phase, the engineering and development phase, and finally, the commercial development phase.

Programs we will be discussing this afternoon all fall into that second phase, the technology and engineering phase. In order to understand those programs and their significance, it's necessary to put them in the context of all three phases.

First I would like to talk very briefly about reprocessing. Reprocessing is the key that can unlock the full potential of nuclear power. It's essential to obtain plutonium for our breeder development programs and for the initial stages of commercial deployment of breeder reactors. It's a fundamental part of our strategy for the management of spent LWR fuel and nuclear waste, and is finally an essential element in establishing the United States as a credible nuclear supplier.

The third phase, commercial development, is also essential for success and we feel it must be conducted by the private sector. Proprietary developments by manufacturers and designers will lead to improvements in the capital costs and performance as industry works itself down the learning curve. This approach will allow free market mechanisms to drive the pace of innovation and commercial introduction in an economically sensible manner.

In the fiscal year 1982 budget, the administration has restored a central line of advance for the breeder program; namely, a sequence of carefully scaled planned projects. The CRBR will be completed as expeditiously as possible. We'll begin on design activities for the large developmental plant, a followup to the CRBR. The base technology program will be sharply focused on supporting the plant projects to decrease the technical risks as we go forward with it.

Finally, the fuel cycle program is developing the equipment and basic concepts needed to meet the unique challenges in reprocessing LMFBR fuel.

I would like to turn to each of these four major elements in our program and discuss them in a little bit more detail.

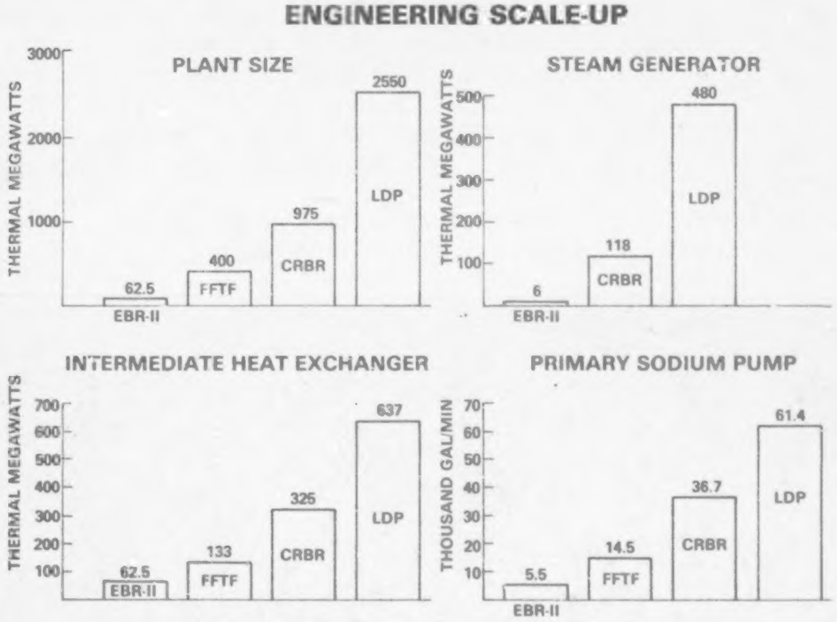
VIEWGRAPH 3

First, viewgraph 3 is a picture of the fast flux test facility which went critical last year in February. We reached, on December 21, full power at 400 megawatts thermal in this facility. It's the largest liquid metal reactor operating in the United States and the largest fast spectrum test facility in the world.

Last Thursday, we completed the highly significant SCRAM 75 percent power, which is confirming all the models that we've had for natural circulation cooling of LMFBR's. This is a very important step in confirming safety models that are used to define the safety levels achieved in the Clinch River project.

In fact, today the fast flux test facility is back up at full power and is planning to scram from full power down to natural circulation tomorrow.

I spoke earlier of a sequence of carefully scaled plant projects as the central line of advance for the breeder program.

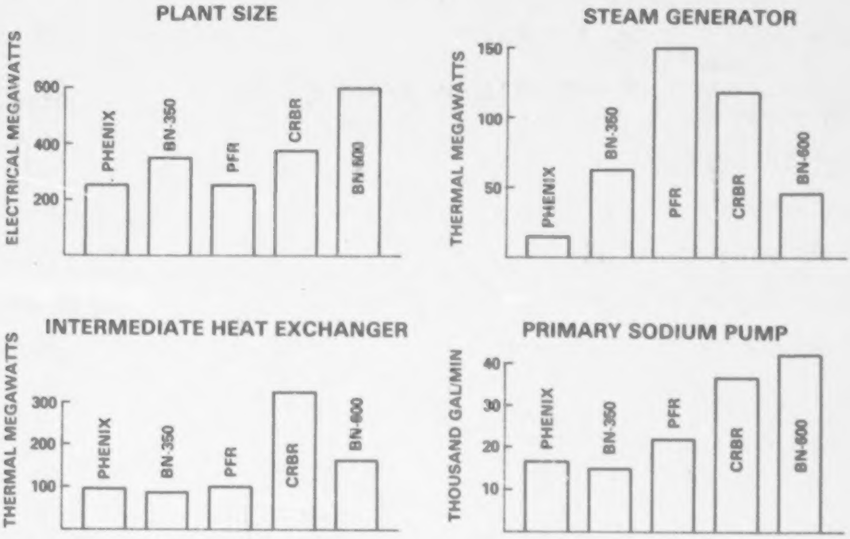


VIEWGRAPH 4

I think viewgraph 4 shows very clearly what we mean in each of the cases. We have plotted on bar graphs not only the total plant size but the size of major sodium components associated with the steam generator, intermediate heat exchanger, and primary sodium pumps.

An essential feature of our national strategy is a gradual engineering scaleup of each of the major components as well as the total plant size. So, as our plants are scaled up, all of the major components are scaled up proportionately.

Viewgraph 5 will compare the Clinch River Breeder Reactor to other breeder reactors in size.


CRBR COMPARISON TO FOREIGN PLANTS

PLANT SIZE

STEAM GENERATOR

INTERMEDIATE HEAT EXCHANGER

PRIMARY SODIUM PUMP

VIEWGRAPH 5

All the reactors shown on that chart are in operation, and you see that although many of the plants are about the same total size as Clinch River, the components often are quite a bit smaller. I think a good example is the BN-600, the large sodium reactor in the Soviet Union, which is rated at 600 megawatts, and yet when you look at the size of the steam generators, they are not even 50 megawatts each; they are 43 megawatts. This is the size of the steam generators used by their plant. So they are using some major sodium components that aren't proportionately scaled to the overall plant size. And that is, I think, one of the key strengths of the U.S. program—the overall balance with which we are scaling the individual components as well as the total plant.

## CLINCH RIVER BREEDER REACTOR PLANT PROJECT

## KEY MILESTONE SCHEDULE
## FEBRUARY 1990 INITIAL CRITICALITY OPTION

| MILESTONE | DATE |
|---|---|
| ISSUANCE BY DOE OF REVISED LMFBR PROGRAM FINAL ENVIRONMENTAL STATEMENT | 8/1/81 |
| NRC STAFF IN PLACE | 11/1/81 |
| NRC AGREEMENT TO START OF SITE PREPARATION | 4/1/83 |
| START SITE PREPARATION | 4/1/83 |
| START MAT PLACEMENT | 6/1/84 |
| START SODIUM SYSTEM TEST | 3/15/89 |
| START FUEL LOAD | 9/15/89 |
| INITIAL CRITICALITY | 2/15/90 |

VIEWGRAPH 6

Viewgraph 6 shows the overall schedules and some of the key milestones for completion of the Clinch River project. You can see, in the early years, that activities related to licensing and the safety review are very much on the critical path. Probably some of the key dates are: Starting site preparation in April 1983; getting a construction permit; and starting mat placement and actually pouring concrete in June 1984. This will lead to our initial criticality in the very early part of 1990.

## RESOURCES CONSERVED BY 30 YEARS OPERATION OF CRBR

| | | VALUE OF REPLACED FUEL (BILLIONS OF DOLLARS) | |
|---|---|---|---|
| | | 1980 CONSTANT DOLLARS | CURRENT DOLLARS |
| COAL | 26 MILLION TONS | $0.9 | $7.1 |
| OIL | 123 MILLION BBLS | 2.7 | 21.3 |
| NATURAL GAS | 700 BILLION $FT^3$ | 1.4 | 11.0 |
| URANIUM | 2400 SHORT TONS $U_3O_8$ | 0.5 | 4.0 |

*1980 PRICES ESCALATED AT 8%/YEAR

VIEWGRAPH 7

Dr. DILLON. Viewgraph 7 shows the Clinch River project will actually begin to pay off in terms of revenues and in terms of electrical energy generated. That is one of the reasons why we are very anxious to get the plant completed. Certainly the programmatic pressure to get the plant completed is the most vital one. But in addition, we will be able to save money in terms of the total project cost the faster we can get it completed, and we will begin to commence electrical generation.

This chart shows some of the fuels that will be saved through the 30-years operations of the Clinch River plant.

Mr. LUJAN. After 1990?

Dr. DILLON. Yes. And gives the value of those fuels in terms of electrical generation, in terms of constant dollars, 1980 constant dollars, and also in terms of what will be the actual yield dollars that we estimate.

### CLINCH RIVER BREEDER REACTOR PLANT PROJECT

### OVERALL STATUS AS OF DECEMBER 31, 1980

| | |
|---|---|
| DEVELOPMENT AND DESIGN | APPROXIMATELY 83% COMPLETE |
| EQUIPMENT | $533 M PLACED ON ORDER<br>$328 M COSTED<br>$124 M IN EQUIPMENT ITEMS DELIVERED |
| LICENSING | FINAL ENVIRONMENTAL STATEMENT AND SITE SUITABILITY REPORTS ISSUED BY NRC<br>ENVIRONMENTAL HEARINGS SUSPENDED IN APRIL 1977<br>NRC IS NOT CONTINUING SAFETY REVIEW |
| COSTS | TOTAL $1000M INCLUDING $888M DOE, $108M UTILITY, AND $4M OTHER |

VIEWGRAPH 8

Viewgraph 8 gives the overall status of the project. Development and design is essentially 83 percent complete. In terms of equipment, out of a total value of equipment of about $960 million we have $533 million placed on order, $328 million has been costed, and $124 million in equipment has actually been delivered.

Total cost incurred as of December 31, 1980 has been $1 billion. We estimate the total cost of completion will be about $2 billion additional.

I would like to quickly cover some of the accomplishments that have been associated with the Clinch River project.

## CRBRP APPLIES ADVANCED ELECTRONICS TECHNOLOGY MULTIPLEXING

- SAVES 1.5 MILLION FEET OF CABLE
- REDUCES CONSTRUCTION SCHEDULE BY 20 WEEKS
- ENHANCES FLEXIBILITY FOR MODIFICATION
- RELIABLE—NOT USED ON SAFETY RELATED SYSTEMS
- HIGH SIGNAL AVAILABILITY
- EXTENDS NUCLEAR INDUSTRY "STATE-OF-THE-ART"

VIEWGRAPH 9

In addition to proceeding systematically with the design there have been several areas where we have been able to make major strides forward. This muliplexing, shown in viewgraph 9, is an example of breakthrough in terms of instrumentation control. By multiplexing signals, that allows us to put several signals through the same cable. We are able to save 1½ million feet of cable. And that is one of the very critical items on our construction schedule. So that allows us to save 20 weeks in the construction schedule. Just as importantly, it will give us increased flexibility for the future because we will be able to put even more signals through a given set of cables in the future when new requirements appear.

We have not used multiplexing for the crucial safety systems, but only for other aspects of plant control.

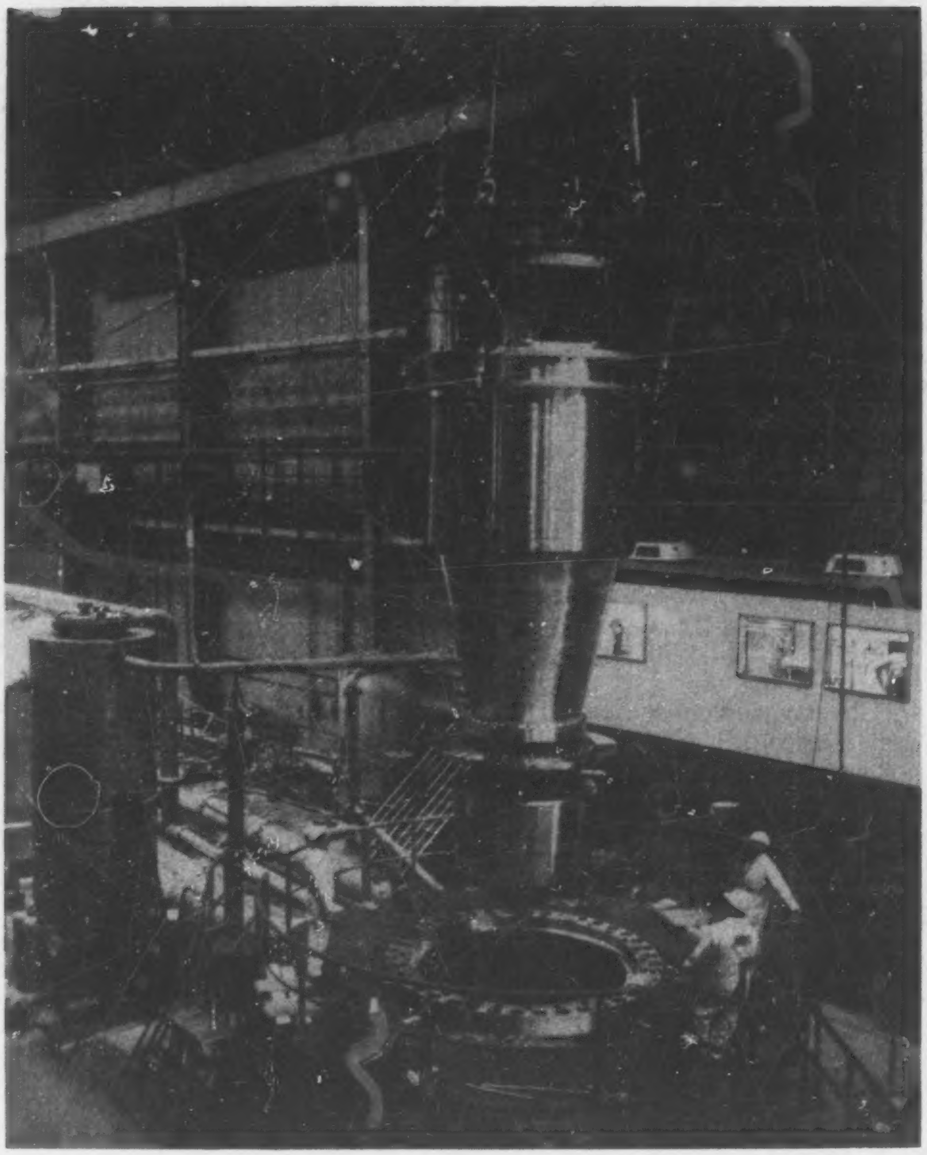
Another point that is related to this, I think, is that there have been an average of about 1,000 engineering change proposals every year for the past 3 years, and they have helped us keep the design completely modern.

Mrs. BOUQUARD. Dr. Dillon, would you excuse me for just 1 minute. We are very happy to have in our audience today Dr. Cockrell and about 15 students from North Carolina State that are studying nuclear engineering. We are happy to have them with us today as part of our group. We hope they will certainly profit from our hearings today.

According to our committee rules, it is necessary for us to obtain permission from the members for taking pictures or using electronic equipment. Without objection—there is no objection, so you may proceed.

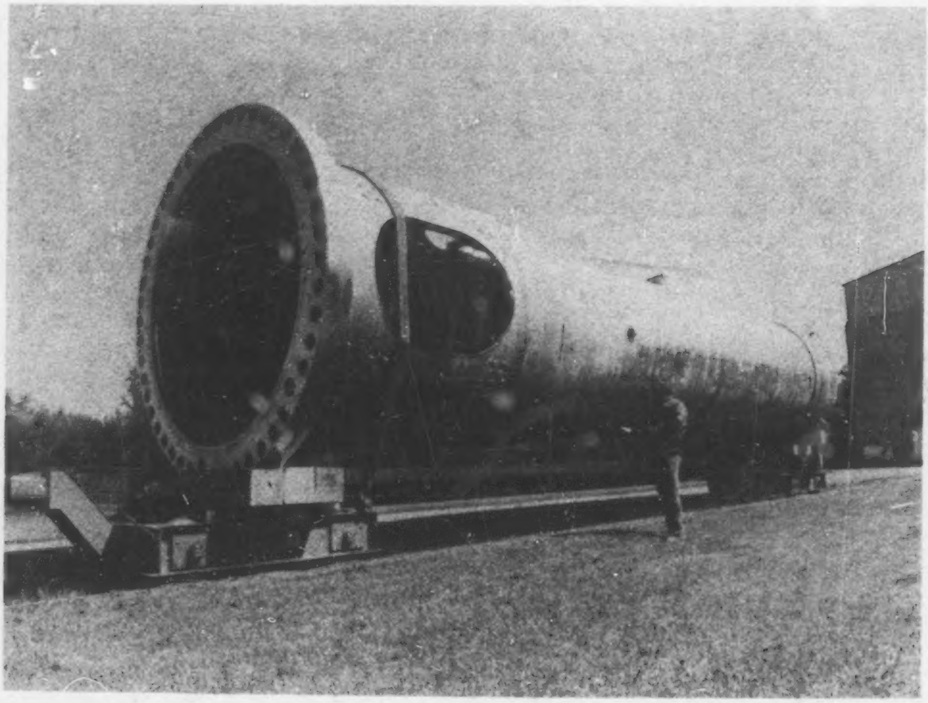
Again we welcome you, Dr. Cockrell, to our hearings today.

Dr. DILLON. In addition, as I have said earlier today, we have been successful in actually building some of the key hardware components.



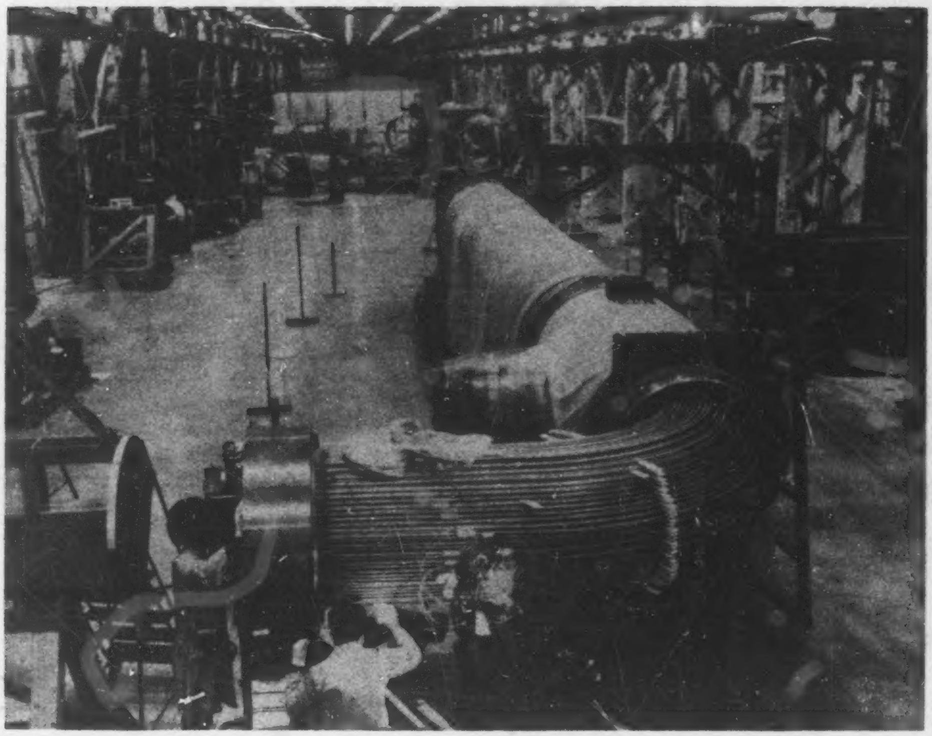
VIEWGRAPH 10

Viewgraph 10 shows a prototype sodium pump that has been built and is undergoing tests, water testing. That particular pump will be shipped to ETEC and tested during fiscal year 1982.



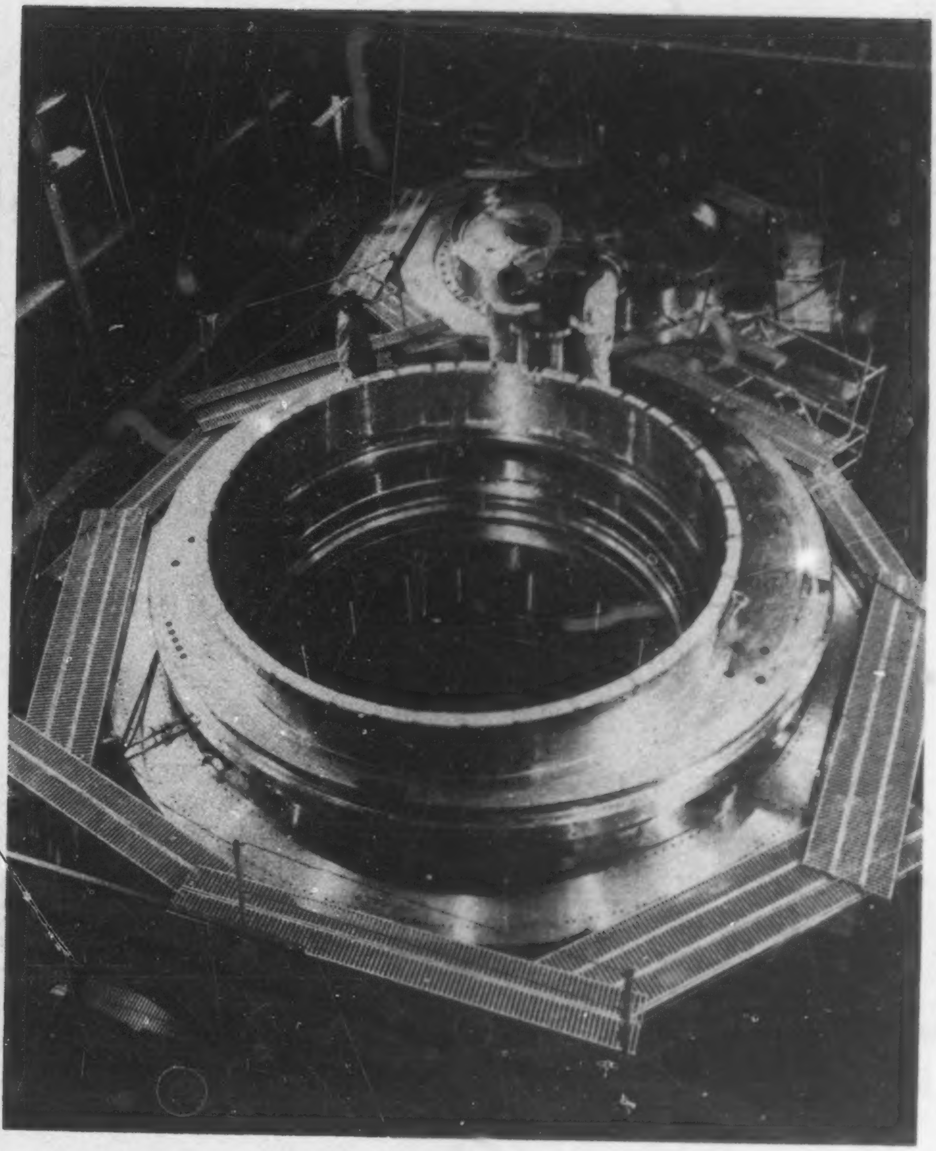
VIEWGRAPH 11

Viewgraph 11 is a picture of the intermediate heat exchanger just prior to shipment to Oak Ridge. Currently these intermediate heat exchangers are at Oak Ridge and in storage.



VIEWGRAPH 12

Viewgraph 12 is a picture of the hockey stick steam generator prototype. We are nearing completion of construction of this prototype and will also ship it to ETEC for testing during fiscal year 1982.



VIEWGRAPH 13

Viewgraph 13 is the reactor vessel closure head, and it, too, is very near completion and fabrication and will be undergoing new testing.

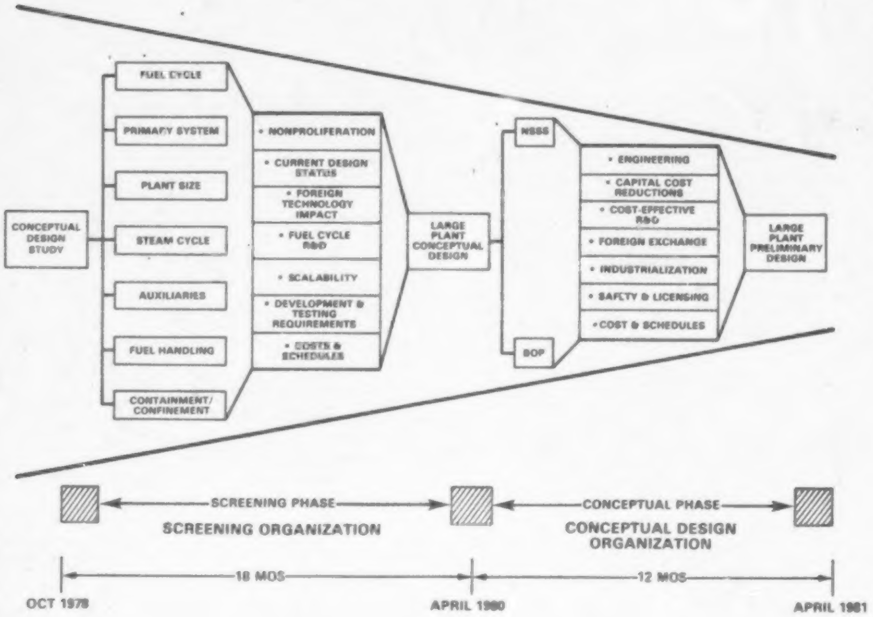
# DEVELOPMENTAL PLANT CAN MEET THE FOLLOWING OBJECTIVES:

- FORMS NEXT LOGICAL STEP IN US LMFBR PROGRAM
- INCORPORATES TO THE MAXIMUM EXTENT PAST LMFBR EXPERIENCE
- FOCUSES THE LMFBR PROGRAM OVER THE NEXT DECADE
- PROVIDES DATA FOR DECISION ON LMFBR COMMERCIALIZATION
- PROVIDES TECHNICAL BASIS FOR INDUSTRY TO COMMERCIALIZE

VIEWGRAPH 14

The next general area is the large developmental plant, shown in viewgraph 14. This is the follow-on that will be necessary after the Clinch River to allow us to scale up to at or near prototypic size for all the major components. It will be based to the maximum degree possible on our experience for the conceptual design study.

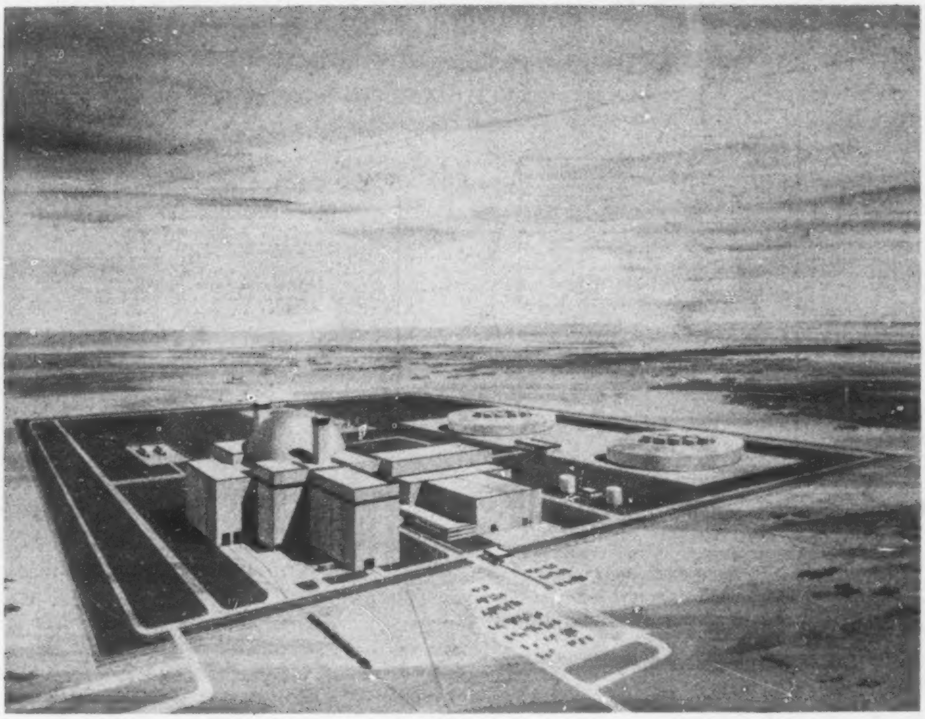
**CDS NARROWING PROCESS**


FUEL CYCLE
PRIMARY SYSTEM
PLANT SIZE
CONCEPTUAL DESIGN STUDY
STEAM CYCLE
AUXILIARIES
FUEL HANDLING
CONTAINMENT/ CONFINEMENT
• NONPROLIFERATION
• CURRENT DESIGN STATUS
• FOREIGN TECHNOLOGY IMPACT
• FUEL CYCLE R&D
• SCALABILITY
• DEVELOPMENT & TESTING REQUIREMENTS
• COSTS & SCHEDULES
LARGE PLANT CONCEPTUAL DESIGN
NSSS
BOP
• ENGINEERING
• CAPITAL COST REDUCTIONS
• COST-EFFECTIVE R&D
• FOREIGN EXCHANGE
• INDUSTRIALIZATION
• SAFETY & LICENSING
• COST & SCHEDULES
LARGE PLANT PRELIMINARY DESIGN
SCREENING PHASE
SCREENING ORGANIZATION
CONCEPTUAL PHASE
CONCEPTUAL DESIGN ORGANIZATION
18 MOS
12 MOS
OCT 1978
APRIL 1980
APRIL 1981

VIEWGRAPH 15

Viewgraph 15 shows the conceptual procedure that was used during the conceptual design study dealing with all the issues associated with what would be the logical next step for our breeder program—what would be the right kinds of components to develop and include in this design, and what would be the most appropriate scale.

Those activities have taken place, and we are planning to submit a report on the conceptual design study at the end of this month.



VIEWGRAPH 16

Viewgraph 16 is an artist's concept of what the large developmental plant might look like based on the characteristics developed in the conceptual design study.

## FUNDING HISTORY
### (MILLIONS OF DOLLARS)

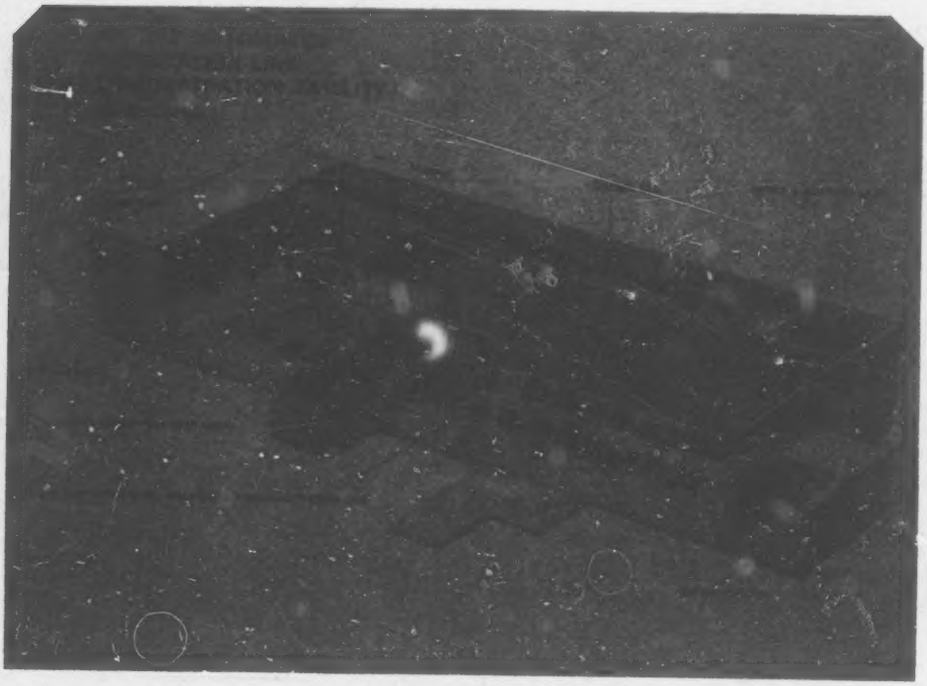
| | FY 1980 | FY 1981 | FY 1982 |
|---|---|---|---|
| FUELS | 46.6 | 40.6 | 42.8 |
| COMPONENTS | 37.4 | 34.3 | 37.2 |
| SAFETY AND PHYSICS | 45.5 | 45.7 | 49.3 |
| MATERIALS | 12.9 | 11.8 | 12.5 |
| TOTAL | 142.4 | 132.4 | 141.8 |

VIEWGRAPH 17

I would like to turn now to the base technology program. Funding for the base technology program, as shown in viewgraph 17, is sharply focused on support for the plant projects; and we're very hopeful that, with that focus, we will be able to keep the high level of progress that we need for the plant projects.

I would like to say that we tried to compare this in terms of constant dollars, to show what the effects of inflation were. If you were to use the GNP inflator for 1980, and what we expect for 1981, the number would be about $168 million for fiscal year 1980, in terms of 1982 dollars; and $143 million in fiscal year 1981.

So, the $141.8 million is actually a continuing trend of production in the base technology program.



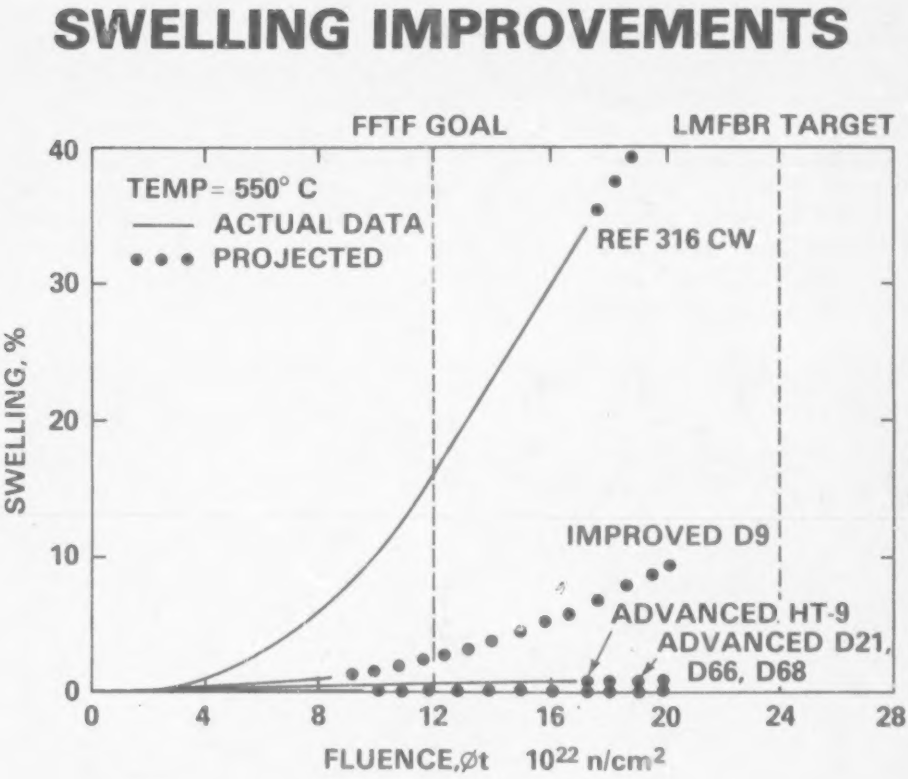
Viewgraph 18

One of the key elements in the base technology program, that's included in both supplemental requests and the fiscal year 1982 budget, is to provide, in the fuels examination materials facility—shown in viewgraph 18—the capability for producing breeder fuels.

Currently, we don't have industrial capability for the production of breeder fuels, and this would give us a capability to produce up to 6 metric tons of oxide every year.

Just to give you a gauge by which to compare this amount, 6 metric tons of oxide would be sufficient to provide for the Clinch River core.

I mentioned that the trend in the base technology program, over recent years, has been toward increased focus on support for the plant projects.



VIEWGRAPH 19

I think that the very successful alloy-screening program, shown in viewgraph 19, is a good example. We looked at literally hundreds of different alloy possibilities, and whittled it down to just two or three of the most attractive candidates.

We are beginning to move this program away from what is now somewhat of a technology development-exploratory development phase, into a much more tightly focused applied engineering activity.

We are working very hard on what's called the D–9 alloy. You can see it has remarkably improved swelling characteristics over the cold worked three-sixteenths of an inch stainless steel. Another one is the HT–9, which has even more desirable swelling characteristics.

So, the program now has been completed, in terms of screening. It is now moving on to its next logical phase, which is evaluating these materials for use in Clinch River, and in the large developmental plant.

# STEAM GENERATOR PROGRAM ACCOMPLISHMENTS

- FABRICATION OF 70 MWe HELICAL COIL
- COMPLETED INSTALLATION OF 7-TUBE MODEL DOUBLE-WALL STEAM GENERATOR
- COMPLETED STEAM GENERATOR THERMAL/HYDRAULIC TESTING

Viewgraph 20

Viewgraph 20 shows some of the results that we have gotten in our steam generator program. A steam generator is probably one of the most important components that there is in the liquid metal reactor.

We are planning now for the steam generators that will be needed for the large developmental plant. We are 50 percent complete with fabrication of a 70-megawatt helical coil steam generator that will test out a design concept that could be scaled up to almost 500 megawatts, and be a candidate for inclusion in a large plant.

We have completed installation of a small, seven-tube model steam generator, and are testing it. This model is based on the double wall approach that has been developed by Westinghouse.

Finally, we have completed steam generator thermal hydraulic testing at Argonne National Laboratory. During that screening, we were able to discover that, in some cases, the heat transfer was less than what had been predicted. And we were able to build on additional length, in terms of the tubing that would be needed to achieve the design rating.

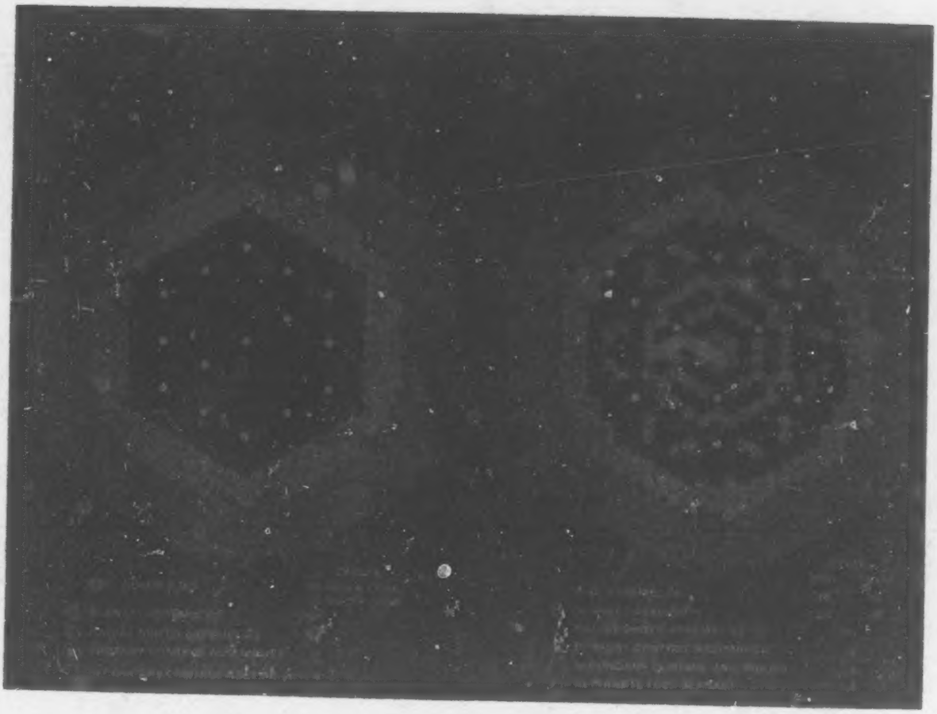
I think it's probably pretty clear that it's enormously easier and cheaper to identify these kinds of problems at this scale and at this level, than after you have built a huge unit and find that it doesn't perform up to specifications.

## CORE PREDICTIONS

- CRITICAL EXPERIMENTS AND ANALYSES ENABLED ACCURATE PREDICTIONS OF FUEL ENRICHMENT AND INITIAL CRITICAL LOADING OF THE FFTF HOMOGENEOUS CORE
- CRBR HETEROGENEOUS MOCKUP CRITICAL EXPERIMENTS AND ANALYSES HAVE ESTABLISHED CONFIDENT DESIGN VALUES FOR BEGINNING-OF-LIFE ENRICHMENT, CONTROL EFFECTIVENESS, AND POWER RATING

VIEWGRAPH 21

As shown in viewgraph 21, we have done core predictions, both for the fast flux test facility and Clinch River breeder reactor. I am pleased to say these predictions confirm extreme precision, in the case of the fast flux test facility, and they give us a great deal of confidence for the predictions we made for the heterogeneous core design used in Clinch River.



VIEWGRAPH 22

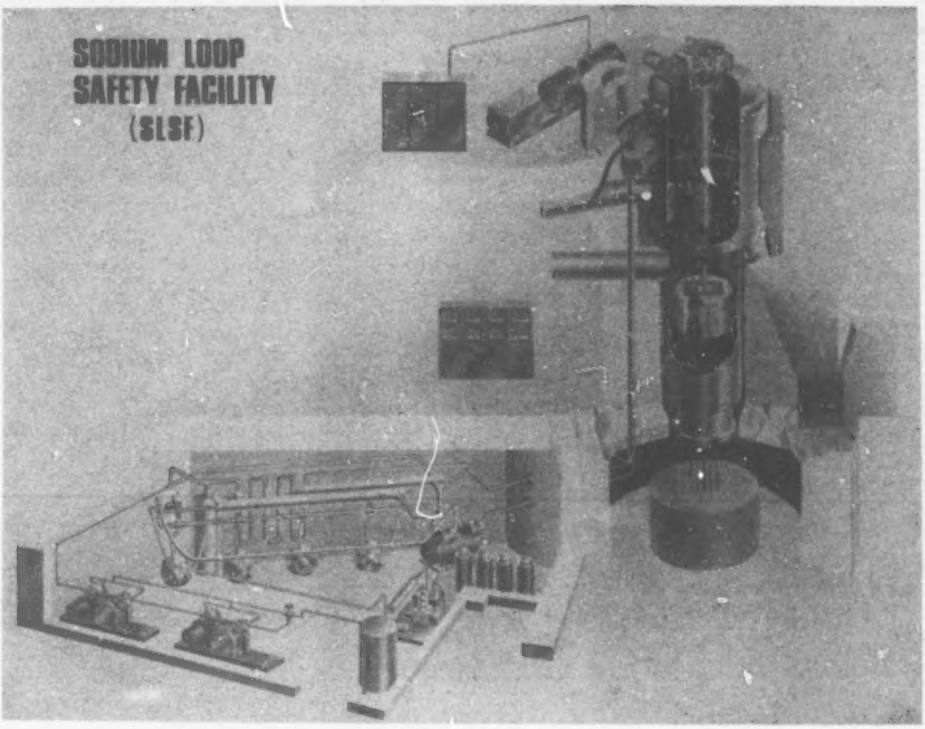
Viewgraph 22 shows what a heterogeneous core means.

You can see a homogeneous core, the kind that's used in many of the foreign reactors. All of the driver fuel that is initially enriched with plutonium is in the center of the reactor, and the blanket is literally that: just a blanket that surrounds the core of driver fuel.

With the heterogeneous core, blanket fuel elements are inserted and dispersed throughout the driver fuel. This gives you several advantages.

One advantage is the breeding gain as the breeding ratio is increased, from what it would have been in Clinch River's case, a breeding gain of about 1.14, up to almost 1.3.

In addition, it allows us to design a reactor with fewer control rods. You need 19 control rods in Clinch River for homogeneous core. You only need 15 in the case of heterogeneous core.



VIEWGRAPH 23

Finally, in the safety area, we are completing a highly successful series of experiments in our sodium loop safety facility (viewgraph 23) in the engineering test reactor in Idaho.

Seven key experiments have been run over the past few years, and have given us some very fundamental information about the behavior of the fuel. Those tests have allowed us to examine the behavior of pin bundles, ranging from 9 pins up to 37 pins, in a number of different kinds of abnormal conditions of either flow transience or sodium blockage-type transience. Or, in one case, a power transient.

# BREEDER REPROCESSING

- RECEIVING/STORAGE
- FUEL DISASSEMBLY/SHEARING
- VOLOXIDATION
- DISSOLUTION
- SOLVENT EXTRACTION
- PRODUCT CONVERSION
- REMOTE MAINTENANCE
- ACCOUNTABILITY
- PROCESS CONTROL

VIEWGRAPH 24

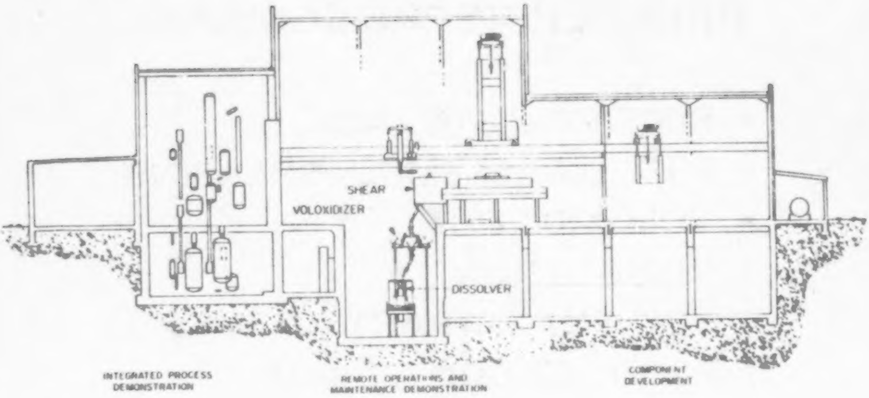
The next key area of the technology and engineering phase has to do with breeder reprocessing, shown in viewgraph 24.

Breeder fuel, because of the higher enrichment and fissile material and because of larger burnups we plan to get, has some unique challenges associated with reprocessing.

The fission products, both in terms of heat burn and in activity levels, will be quite a bit higher in breeder fuel than in LWR fuel. In addition, there will be strong economic pressure to keep the amount of storage time, during which breeder fuel is cooling off, to a minimum, so that we can reprocess the valuable fissile material back into circulation.

So, because of that, there will be many areas where we have to do technology development at this stage: Receiving and storage of fuel, disassembly, voloxidation, dissolution. These are all key technical areas that will require new equipment. In some cases, even new concepts.

The remote maintenance and accountability process control are examples of general areas that will cut across the entire plant, where a great deal of work needs to be done, in anticipation of reprocessing the breeder fuels.

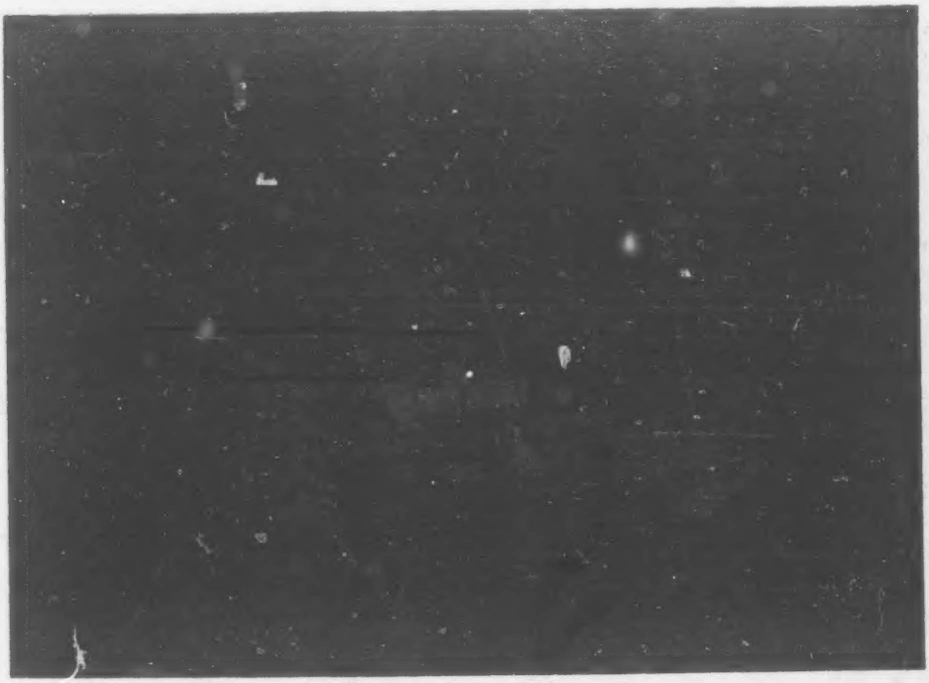

SHEAR
VOLOXIDIZER
DISSOLVER
INTEGRATED PROCESS DEMONSTRATION
REMOTE OPERATIONS AND MAINTENANCE DEMONSTRATION
COMPONENT DEVELOPMENT

VIEWGRAPH 25

Viewgraph 25 shows a cutaway of the integrated equipment test facility at Oak Ridge National Laboratory.

This is a facility where we plan to test both key element and equipment elements and concepts as well, on a cold basis—in other words, without radioactive materials—to verify their performance. We will put all of the key components together, integrate them, and then see, finally, how they will operate as a system.

This will be the basis for an actual hot experimental facility, as shown in viewgraph 26.

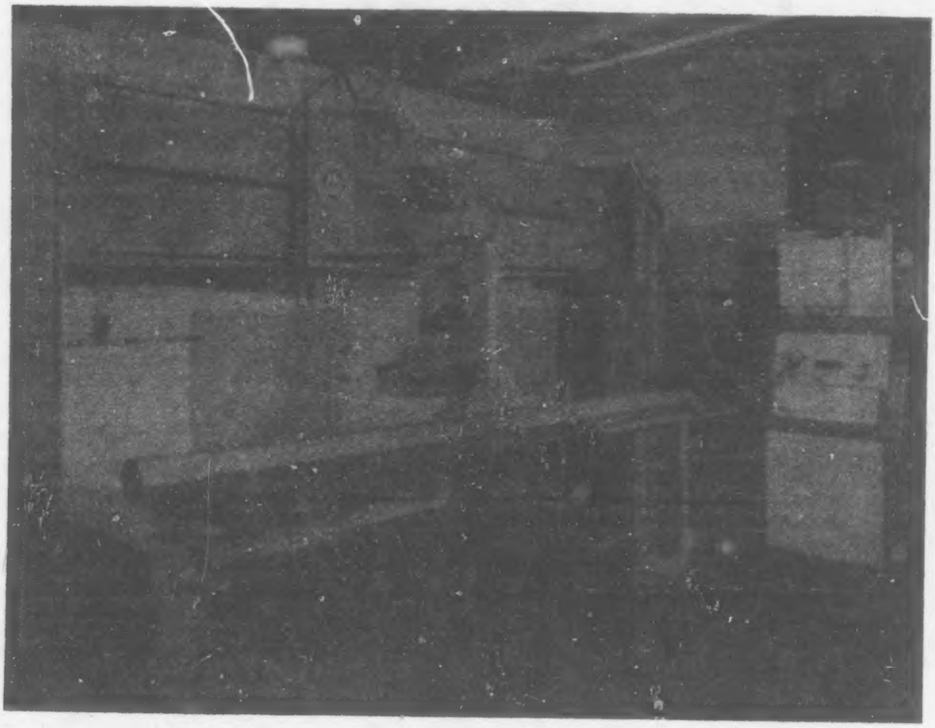


VIEWGRAPH 26

Even though we don't expect operation of such a facility that could reprocess actual breeder fuels for quite some time, we have done, even at this early stage, some conceptual design activities to help focus our basic technology program in this area.

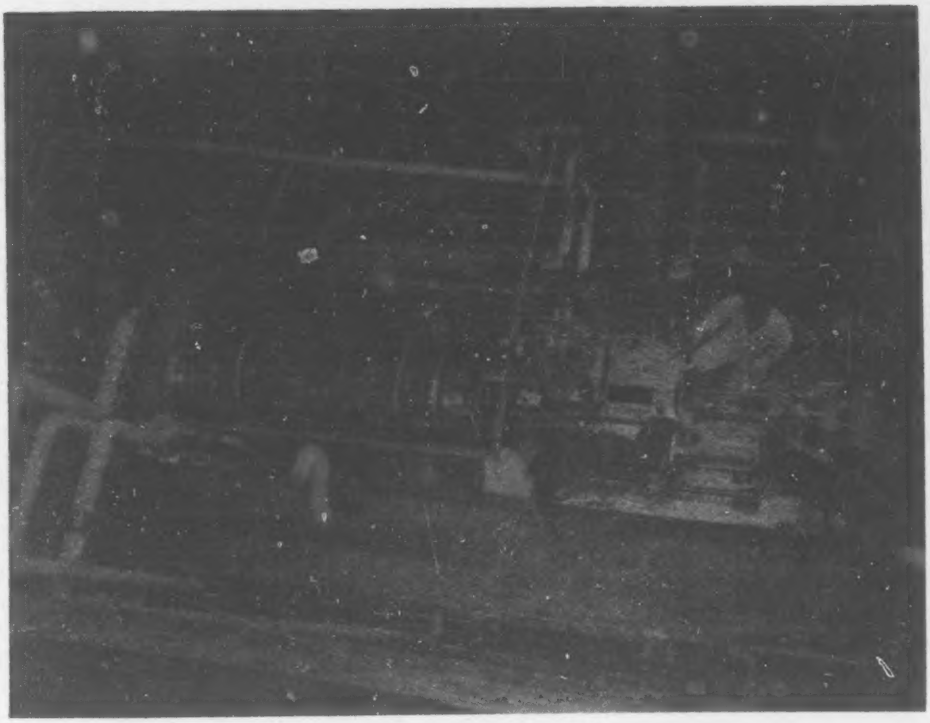
This is an example of some of the accomplishments we've had recently in this program. It is a laser approach to disassembling. It's very important, in fact essential, for breeder fuel elements to be able to take the outside shroud off of the fuel element before you try to cut them up and begin the reprocessing.

This technique uses a laser to do the cutting.



VIEWGRAPH 27

That laser shown in viewgraph 27 is able to cut through that ⅛-inch stainless steel shroud at the rate of 50 inches a minute, so it's very effective. It also allows us to keep the business end of the equipment—the laser itself—outside the cell. And that makes the issues of maintainability much simpler.



VIEWGRAPH 28

The next area is the dissolver, shown in viewgraph 28.

Dissolution of high burnup breeder fuel poses a more formidable problem than it does in the case of LMFBR fuel. And this technology has been developed and demonstrated and, I think, promises to deal with that quite effectively.

That concludes my overview of some of the main accomplishments and strategy we have in the breeder program.

In summary, I would like to say that I think the breeder program is back on track.

Carrying out this program will put our commercial industry in a position—certainly, by the turn of the century—where they can make decisions and choices. The program will also do the hard work that would be necessary to make the breeder reactor a viable commercial option for our utilities.

I would like to thank you very much, and we'd be happy to answer any questions you have, at this time.

[The prepared statement of Dr. Dillion follows:]

Statement of
Dr. Thomas A. Dillon
Deputy Assistant Secretary
for Nuclear Reactor Programs
Department of Energy
House Science and Technology Hearings
March 17, 1981

Madam Chairman and Members of the Committee, it is a pleasure to appear before you to discuss the Department of Energy's nuclear reactor research and technology program. I am accompanied today by Mr. Robert Staker, Director of the Office of Reactor Research and Technology. The Office of Reactor Research and Technology is responsible for our Liquid Metal Fast Breeder Program. The budget request contains four major program parts--The Clinch River Breeder Reactor (CRBR) Project; Breeder Reactor Studies (Conceptual Design Studies); the Liquid Metal Fast Breeder Reactor (LMFBR) Base Program; and Fuel Cycle Research and Development. A general discussion of program objectives, organization, and accomplishments is contained in my formal submittal for the record. I would like to devote a few minutes to the strategy underlying our breeder program. I will then be happy to answer any questions you may have.

## PROGRAM STRATEGY

Nuclear is one of two principal energy sources for meeting the U.S. electrical energy needs over the coming decades. It is now, and will continue in the future, to play a major role in reducing our dependence on oil for electric generation. In addition, I believe that nuclear power will be absolutely essential to support increases in economic growth.

The breeder reactor, an essentially inexhaustible source of electrical energy, is a key element of an overall domestic energy strategy to achieve a safe, domestic supply of economical energy to support a healthy economy. The breeder is the logical next step in the evolution of nuclear power development. As the natural uranium resource base becomes committed, breeders will increasingly become the choice for new capacity. The purpose of our breeder program is to conduct the necessary research, development, and demonstration activities to ensure that a breeder reactor is available to this country.

Timing of breeder introduction and long-term commercial prospects are uncertain. While numerous studies have undertaken to answer the question "when is the breeder needed?", it will be the marketplace that will determine the commercialization of the breeder. Some studies show that breeders will be economically competitive with light water reactors around 2010, while others indicate a range in the 2020-2030 time period. In any event, given the time required to conduct the necessary research and development projects associated with such a complex technology, we must begin our scale-up engineering activities now.

## PROGRAM ORGANIZATION

The major thrust of the Breeder Reactor Systems Program is in the Liquid Metal Fast Breeder Reactor Program, its associated fuel cycle, and program direction. The budget request for this activity for FY 1982 is $678.5 million in budget authority, including $10.6 million for program direction. In FY 1981, $552.6 million was requested, including $11.2 million in program direction.

## LIQUID METAL FAST BREEDER REACTOR (LMFBR)

The LMFBR program objective is an engineering scale demonstration of LMFBR viability as an essentially inexhaustible energy production option for the U.S. This effort includes the design, construction and operation of LMFBR facilities supported by a strong program of research and development including the operation of required test facilities. Statutory authority for these activities is contained in the Atomic Energy Act of 1954, as amended (P.L. 83-703) and in the Atomic Energy Commission Authorization Act for FY 1971 (P.L. 91-273). The budget request for the LMFBR is summarized below:

| | FY 1981 | Supplemental a/<br>(in thousands) | FY 1982 |
|---|---|---|---|
| CRBR | $122,000 b/ | $ 50,000 | $254,000 |
| Breeder Reactor Studies | 7,500 | - | 15,000 |
| LMFBR Base Program | 364,419 | 18,000 | 372,842 |
| | $493,919 | $ 68,000 | $641,842 |

a/ Supplemental funds being proposed
b/ Funds provided by PL-96-369 and by PL-96-536

### Clinch River Breeder Reactor Project (CRBR)

The principal objective of the project is to design, construct and operate a 375 megawatt electric liquid sodium cooled breeder reactor power plant. This project will provide important information regarding safety, environmental advantages, and economic potential of LMFBR's as an essentially inexhaustible, domestic energy source.

The project is well underway in the design and hardware procurement areas and is in a position to begin site clearing and construction upon receipt of the necessary approvals.

Significant program accomplishments through FY 1981 will include:

- Completion of overall plant design is expected to be about 86 percent. Completion of project funded research and development is expected to be about 96 percent.
- Completion of about 7,045 architect-engineering drawings of the total required number of about 9,400 drawings.
- Placement of procurement contracts for approximately $540M of hardware.
- Manufacturing completion of approximately $218M of hardware, with $161M of effort accomplished on other hardware in process.
- Contribution to the advancement of the worldwide state-of-the-art in LMFBR plants, such as the heterogeneous core.
- Continuous evaluation and updating of the plant design to remain current with changing regulatory requirements.
- Resumption of a working relationship with the Nuclear Regulatory Commission staff.

A supplemental appropriation of $50 million is being requested to carry the project through FY 1981. Previously enacted FY 1981 appropriation acts have provided $122 million for continuation of the project through June 5, 1981. The supplemental of $50 million will permit the orderly conduct of project activities throughout the fiscal year.

Planned accomplishments in FY 1982 include:

- Completion of overall plant design is expected to rise to about 92 percent. Completion of the research and development is expected to rise to about 98 percent.
- Completion of architect-engineering drawings is expected to rise to about 8,900 of the 9,400 required.
- Placement of procurement contracts for about $150M of hardware. Also, release to fabrication of currently placed procurements including the turbine generator, the containment vessel, plant unit steam generators, chilled water system chillers, the air blast heat exchanger, the ex-vessel transfer machine and gantry, and the large component cleaning vessel.

- Manufacturing completion of about $30M of hardware, resulting in a total of $248M in hardware completions. An additional $210M in effort will have been accomplished on other hardware been accomplished on other hardware still in process.
- Resolution of any open technical issues with the NRC staff.
- Mobilization of the construction force and placement of procurement orders for long-lead items such as the concrete batch plant, quarry equipment, rock crushers, heavy cranes and other construction equipment.

## Breeder Reactor Studies

The Conceptual Design Study (CDS) being accomplished under this activity is composed of two phases. The first phase, which was completed in FY 1980, consisted primarily of evaluations and trade-off studies to select key technical parameters for a Developmental Plant in the 1000 MWe size range. The second phase of CDS, which was initiated in mid-FY 1980, is developing a conceptual design of an LMFBR Large Developmental Plant (LDP). A comprehensive report on the LDP conceptual design will be presented to the Congress by March 31, 1981.

## Large Developmental Plant

In FY 1982 the detailed design of an LMFBR Large Developmental Plant will be initiated. This design will build on the conceptual design activities conducted under the CDS in fiscal years 1979-81 and will directly incorporate the experience gained from the CRBRP project. The plant design will stress simplicity and inherent safety, will have sufficient flexibility to generate essential technical data while operating reliably to produce electricity for use on a utility grid, and will represent significant state-of-the-art advancements in LMFBR technology in the 1990's. By performing detailed design on the key Developmental Plant systems, this project will provide an effective focus for the LMFBR R&D activities in the areas of safety, fuels development, materials and large components. The large Developmental Plant design that evolves will constitute the next logical step in the U.S. LMFBR program and will, during its design, construction and operation, generate the data required to support a future decision on whether the LMFBR should be commercially introduced in the U.S.

## LMFBR Base Program

This program strategy is structured around three major elements: Breeder Technology, the Fast Flux Test Facility Program, and Test Facilities. Supporting this program is a Safeguards and Program Assurance effort, and an Inventory account for procurement of fuel and process spares.

## Breeder Technology

Breeder technology development solves long lead-time technical problems on the critical path of reactor demonstration and eventual commercial acceptance. Five program subelements are used to accomplish this: engineered systems and components, fuels and core design, materials and structures, physics, and safety.

Engineered systems and components encompasses design, fabrication, and testing of prototype and model components to ensure that reliable and economic components are developed for use in large (1,000 MWe) breeder reactor plants.

Experience with breeder reactor plants in this country (EBR-II and Fermi) and abroad (PFR, Phenix, BN-350) has shown that heat-transport components have been the major source of plant operational deficiencies. Thus, development emphasis is on long-lead and unproven but essential components such as steam generators and main coolant pumps. Also, the scale-up in capacity required from component designs for the Fast Flux Test Facility--FFTF--(factor of approximately 6) and CRBR (factor of approximately 2), coupled with more severe requirements in some cases, necessitates significant additional development and demonstration testing. To avoid the potential impact to the U.S. power generation capability of a generic component problem in a widely deployed reactor type (similar to that experienced with PWR steam generators), reactor plant components must be developed and tested prior to utilization in breeder reactor plants. Supporting development in areas such as vibration and mixing are carried out to successfully complete component development. In addition, test activities are carried out to support the CRBR.

Of the major components, the steam generator requires the greatest development; and demonstration of a reliable, economic steam generator has not yet been achieved either in this country or abroad.

FY 1981 accomplishments in the steam generator program include:

- The design of the single-wall tube 70-MWt model steam generator will be complete, and fabrication will continue.
- Testing of a few-tube model of the double-wall steam generator will be complete.
- Fabrication of the double-wall tube 70-MWt model steam generator will begin.
- Following the initial series of sodium-water leak tests already completed in the Large Leak Test Rig (LLTR), the six tests of a second series employing a full-diameter (CRBR) test vessel will have been conducted.

In the pump program:

- The water model testing in support of the 85,000 gpm reference primary, alternate primary, and intermediate pumps will be complete.
- Fabrication of the reference primary pump and the intermediate pump will be initiated.
- The intermediate size inducer pump testing will be complete.

In the supporting development area:

- Adaptation of a thermal/hydraulic code (COMMIX) for intermediate heat exchanger (IHX) application will be complete.
- Testing of small valves will continue along with the associated data analysis, test article examination, and reporting.

In the CRBR support area:

- Testing of the CRBR in-vessel fuel transfer machine will be completed.

FY 1982 activities in steam generator development, the highest priority component activity, will be as follows:

- The final design analysis and fabrication of the single-wall tube 70-MWt steam generator model will be completed and the model will be shipped to the Energy Technology Engineering Center (ETEC) for sodium testing.
- The design of the double-wall tube 70-MWt steam generator model will be near completion by the Westinghouse Nuclear Components Division. Fabrication of the model will proceed at a low level.
- Evaluation and reporting will be completed for the large leak tests being conducted in the large leak test vessel at ETEC.
- Acoustic and chemical leak protection systems will be installed and tested commensurate with a limited performance test on the CRBR prototype steam generator to help define a recommended leak protection system.

Major development is also required on primary pumps with expected progress in FY 1982 as follows:

- The final design of the 85,000 gpm reference primary pump will be completed by Westinghouse Electro-Mechanical Division and prototype fabrication will be continued.

- The final design of the intermediate pump by Byron Jackson will be near completion and limited prototype fabrication will be initiated.

- The alternate primary pump design by Atomics International will be near completion and water testing of a model pump at ETEC will be completed.

In the supporting development area, substantial progress will be made as follows:

- Argonne National Laboratory (ANL) will continue management of large component activities and will develop design guides on the effects of fluid damping on circular cylinders (e.g., heat exchanger tubes and reactor fuel rods) and on pipe flow stratification.

- The verification of the system thermal/hydraulic computer code (DEMO) will be completed by Westinghouse Advanced Reactors Division using FFTF operating data.

- The testing required to provide initial verification of the COMMIX heat exchanger thermal/hydraulic computer code will be completed at ANL.

- The initial phase of qualification of small, commercially available valves for liquid sodium service will be completed at ETEC.

In the CRBR support area, progress is expected as follows:

- CRBR steam generator prototype limited steady-state testing in sodium at ETEC will be initiated.

- CRBR prototype pump (34,000 gpm) limited testing in sodium at ETEC will be completed.

Fuels and core design encompasses reactor fuel system and fuel fabrication development and assurance of fuel supply for the LMFBR. Two major goals are pursued:

- Provide safe, reliable, economical fuel systems in support of the breeder energy option by utilizing and improving highly successful mixed oxide fuels, selectively developing promising higher performance advanced fuel systems, and developing and testing improved alloys for use in long-life fuel, blanket and control core components.

- Develop an adequate fuel supply capability to support FFTF and/or future breeders that reduces personnel radiation exposure, enhances special nuclear material safeguards and accountability, and provides high quality, low-cost fuel.

Significant program accomplishments through FY 1981 include:

- Fabrication of four complete core loadings of high quality FFTF driver fuel pins.
- Completion of successful testing of over 2900 fuel pins in the Experimental Breeder Reactor II (EBR-II), in preparation for FFTF operations and testing. Over 400 of these have been tested beyond their design lifetime.
- Completion of more than 50 reference mixed-oxide fuel pin transient tests that have established reference fuel operating limits.
- Completion of design on 33 FFTF fuel and blanket irradiation tests. Fifteen of these tests have been fabricated.
- Doubling from 1 to 2 years the FFTF control assembly lifetime. A design for a 3-year absorber assembly has been successfully tested out of the reactor.
- Completion of irradiation testing of the reference clad/duct alloy cold-worked 316 stainless steel. Testing of alloy D9, which exhibits a four-fold swelling improvement (reduction) is nearing goal neutron fluence.
- Development of most of the operations required for automated fuel fabrication equipment suitable for integration into a remotely operated fuel fabricated line. Operations included are powder preparation, pellet pressing, sintering, pellet inspection and fuel pin welding.
- Completion of the conceptual design of the Secure Automated Fabrication (SAF) line. This line is designed to provide FFTF driver fuel while demonstrating technology to reduce personnel radiation exposure, to enhance special nuclear materials safeguards (accountability and physical protection), and to improve fuel quality and cost.

Key accomplishments in FY 1982 will include:

- Complete initial examinations of FFTF driver fuel to verify performance.
- Continue instrumented FFTF irradiation testing of improved and advanced clad/duct alloys.
- Automate and integrate prototype SAF line equipment.
- Initiate detailed SAF line design.

During FY 1982, principal program effort leading to these accomplishments includes:

- The initial FFTF partial core loading of prototypic Conceptual Design Study (CDS) oxide fuel assemblies will be delivered. Fuel pin transient tests will be conducted in the Transient Test Reactor (TREAT) and EBR-II. Performance tests of advanced absorber assembly designs as well as full scale testing of long-life fuel system components will be initiated in FFTF.

- The irradiation of improved cladding/duct alloys will continue in the FFTF Materials Open Test Assembly, with specimen discharges at the end of each cycle. Discharge fluences will approach goal fluences for FFTF components.

- Advanced equipment development for all fuel pin fabrication operations, including material transfer and storage, will be underway. Process engineering design supporting fully integrated line operation in Fuels and Materials Examination Facility (FMEF) will be conducted. Automated pin loading systems development will be completed. Transfer and in-process storage systems will be designed and procurement initiated. Integration of process instrumentation and control systems will continue. SAF line conceptual design will be completed in preparation for initiation of detailed design.

- The post-irradiation examination of the reference and improved FFTF/CRBR core components will be initiated. The results of these examinations will be incorporated into improvements to design codes and performance models. The FFTF performance data will be supplemented by pin performance evaluations from completed EBR-II tests, and thermal-hydraulics codes will be updated on the basis of data from instrumented FFTF tests. Pin spacer methods will be evaluated on the basis of FFTF irradiation test results.

Materials and structures encompasses efforts to ensure that LMFBR components and systems will be free from structural failures, and to develop materials, design methods and criteria, materials property data, and procedures. Products include technical guidelines, design rules, data, and documentation.

FY 1982 program restructuring focuses on the highest priority needs of a plant up to the 1000 MWe size range. Planned accomplishments prior to FY 1982 include:

- Development of guidelines on soil/structure interaction method for asymmetrical structures.

- Completion of the evaluation of large-diameter steel pipe representing a variety of fabrication methods.

- Development of procedures for in-service inspection of steam generator tubing.
- Extension of simplified inelastic analysis methods to more general design applications.
- Establishment of composition limits for the advanced 9 Cr-1 Mo ferritic alloy to be used in LMFBR steam generators.

Planned accomplishments in FY 1982 include:

- Issuance of ground motion prediction procedures for near-field earthquakes.
- Evaluation of the CRBR prototype transition joint design will be completed in the Transition Joint Life Test.
- Completion of the analysis of process variables in component cleaning and decontamination.
- Issuance of unified inelastic constitutive equations for 2 1/4 Cr-1 Mo stell for trial use.
- Completion of intermediate diameter (8 inch) piping system seismic simulation testing to validate seismic design methods for CRBR heat transport system piping.

Physics projects establish and maintain analytical design capability and data needed for development of LMFBR plants. Analytical capabilities are provided in the form of computer codes for interpretation of physics experiments applicable to LMFBR design. Physics data include cross sections and other nuclear properties and other information measured in critical assemblies, shielding mockups, and operating reactors.

Major program accomplishments through FY 1981 are:

- Benchmark critical experiments for both homogeneous and heterogeneous cores. These experiments provide the basis for validating analytical design methods.
- Analysis of decay heat loop shielding requirements of a developmental plant.
- Critical experiment mockups of CRBR sized heterogeneous cores for design and safety data including fuel loading, power distribution, control worths and reactivity feedback maps.

- New fission product, activation and gas production data files for Evaluated Nuclear Data File (ENDF/B-Version V), the only broad, verified nuclear physics data compilation in the world.

- A two dimensional transport code (TWODANT) for economic, accurate benchmark calculations of radiation and power distributions in heterogeneous LMFBR cores.

A major need requiring early action after completion of the FY 1981 physics program is the conduct of shielding experiments to test alternate materials for optimizing shielding costs, volume, weight, and easing of structural requirements of developmental LMFBRs. Other needs include a heterogeneous benchmark critical experiment in the Zero Power Plutonium Reactor (ZPPR) to scope fuel loadings, power distribution, and control worth for large developmental reactors; diagnostic critical experiments; nuclear data measurements and updates, supporting studies of FFTF characteristics, new computer codes and development of new analytic methods, and timely analytical evaluations of developmental fast reactor concepts and designs.

FY 1982 planned accomplishments include:

- Perform generic critical experiments to characterize fuel configurations, control arrangements and sodium void reactivity for large heterogeneous cores.

- Analyze tests discharged from United States and United Kingdom (U.S./U.K). actinide irradiations to obtain nuclear cross section and materials data.

- Analyze FFTF radiation surveys to assess the performance of the FFTF shielding design.

- Document FFTF core characterization measurements and thus baseline FFTF radiation field intensities and spectra for planning fuels and materials tests.

- Complete advanced (variable triangular mesh) three dimensional neutronic design codes with simultaneous control assembly sequencing for more detailed and accurate determination for design of fuel load sequences, control requirements, magnitude and location of power-limiting peaks during operations, and breeding.

- Test new coarse mesh and nodal methods to assess near-term feasibility of efficient three-dimensional codes for detailed shield design and space dependent kinetics.

- Perform analyses of highest priority reactor physics issues generic to advanced, large-scale LMFBRs.

Safety activities are coordinated between projects and the technology base program to ensure that LMFBR designs and systems meet requisite levels of safety. Program activities are organized along Lines of Assurance (LOA's) as a technique of management and as a means for communication and introduction of risk concepts. There are four LOA's:

- LOA-1: Prevent Accidents
- LOA-2: Limit Core Damage
- LOA-3: Maintain Containment Integrity
- LOA-4: Attenuate Radiological Consequences

LOA-1 development calls for demonstration of reactor system reliability in preventing the occurrence of events that would require actuation of the reactor shutdown and shutdown heat removal systems, and for demonstration of the reliability of those systems in terminating reactor transients. Man-machine interface R&D is included. In FY 1982:

- The results of a long-term hardware development and testing effort to assess the operational reliability of candidate LMFBR reactor shutdown and shutdown heat removal systems, as well as the reliability of major LMFBR plant structures such as the reactor vessel and internals, will be evaluated in preparation for future reporting.

- A comprehensive plan for long range man-machine interface R&D for LMFBR powerplants will be completed.

Both of the above activities will reflect coordinated efforts of national laboratories and industrial reactor-vendor contractors.

The objective of LOA-2 development is to show that the inherent response of the reactor system will limit damage to the reactor core, assuming that initiation of an accident has not been prevented. Thus, the capability of the reactor system to accommodate faults in the shutdown and shutdown heat removal systems, as well as local faults within the reactor core itself, must be demonstrated. In FY 1982:

- Program planning for future hardware demonstration of the capability of LMFBR shut-down heat removal systems to function under natural circulation (and possibly degraded) conditions will be initiated. This demonstration is required in order to support safety review of an LMFBR plant design.

- A program plan for the final development phase of one of several candidate self-actuated reactor shutdown systems will be issued. These systems are unique in that they do not require any control system signal or human action in order to provide their protective function--they are triggered by off-normal conditions within the reactor itself, such as high sodium temperature or low sodium flow.

LOA-3 development addresses the potential of hypothetical core-disruptive accidents to produce excessive loadings on reactor and containment structures through short-term energy releases or through longer-term thermal effects. These phenomena are studied with in-reactor and out-of-reactor experiments, and through the development of computer code analyses that model large reactor behavior.

- o The LOA-3 experimental program will continue in FY 1982, and will include tests in the TREAT reactor, under a US/UK cooperative program. Experimental program support for the construction of TREAT upgrade will continue at an increased level.
- o The experimental validation of codes for the prediction of accident energetics and the behavior of plant containment structures under accident conditions will continue.
- o A recommended approach to the accommodation of molten core debris within the reactor vessel will be developed.

LOA-4 work includes the development of engineered systems for reducing potential releases of radioactive material from containment, and investigation of inherent attenuation mechanisms such as dispersion of airborne materials. In FY 1982:

- o Recommendations on the design of reactor plant air cleaning systems will be developed.
- o An evaluation of analytical models of the transport of radioactivity in the natural environment will be continued.

Both activities will reflect the results of extensive testing of the behavior of accident-generated aerosols and equipment to control them.

- o LOA integration work on the collection of plant system and component reliability data, on integrated accident analysis, and on overall accident risk assessment will continue. A major report on risk analysis methodology will be planned.

Fast Flux Test Program

The FFTF is a 400 MWt liquid metal (sodium) cooled fast-neutron-flux reactor designed specifically for irradiation testing of nuclear reactor fuels and materials for fast breeder reactors. It is located at the Hanford Engineering Development Laboratory (HEDL) in Richland, Washington. The FFTF plays a key role in development and testing activities. It provides a test bed for demonstrating and evaluating the performance of future breeder reactor fuel assemblies and partial core loadings at reference conditions.

Although FFTF, as a testing reactor, is not designed to breed fuel or to produce electricity, it provides vital information for plant design and base-technology programs in the areas of: plant system and component design, component fabrication, prototype testing, and large plant construction, testing, and startup. In addition, FFTF provides experience in the operation of a large reactor plant having coolant loops and components at temperatures and coolant velocities nearly typical of large LMFBR power plants. This experience combined with the operating and maintenance experience from other test facilities provides a proven baseline for scaling up systems and components. FFTF will be used to test fuel elements up to and including failure under dynamic sodium-fuel conditions to establish ultimate capability and failure modes. Understanding of failure modes is essential to establish reactor core reliability, performance, and lifetime. It is used in tests to develop the advanced fuels and the advanced cladding and duct materials essential to attaining operational breeding ratios in the 1.25 to 1.3 range with fuel-doubling times of less than 15 years.

Milestones completed thus far are:

- Criticality
- Low power physics testing
- Initial fullpower operation
- Natural circulation test verification from 35 percent power

The FY 1982 funding will provide for:

- Completion of preparations for normal plant operation and irradiation testing.
- Plutonium conversion costs for materials for the FFTF and associated development programs.
- Plant operating and maintenance labor, materials and services to support facility operation.

## Test Facilities

The major objectives of the Test facilities effort are to provide, maintain and operate test facilities and multiprogram sites at HEDL, ETEC, Idaho National Engineering Laboratory (INEL), and ANL to meet program requirements and schedules established by breeder technology support efforts for plant development. In meeting these objectives, design, prototype testing, construction, operation and maintenance experience is provided to base technology and plant projects. Thus, a proven baseline for scaling up systems and components is established.

The ANL effort will be largely accomplished in Idaho (ANL-West). Operating funds will be used at the ANL facilities to cover facility operations, operating personnel, and maintenance, materials, and other support activities.

Operating funds will also support the following activities: continuation of Special Nuclear Material physical control, accountability and management; maintenance of surveillance of the safeguards construction program; assurance of conformity with the site specific safeguards plan; and required support for ANL operation.

The facilities to be operated are discussed below:

- The EBR-II is a 62.5 MW(T) - 20 MW(E) sodium-cooled pool-type fast reactor at the Argonne National Laboratory (ANL)-West site of the Idaho National Engineering Laboratory, operated by the ANL for DOE. EBR-II is currently used primarily for safety, fuels and materials irradiation experiments.

- The Hot Fuel Examination Facility (HFEF) comprises two adjacent hot cell complexes - HFEF North and HFEF South - located at INEL and operated by ANL. The South complex contains two heavily shielded hot cells, one with an argon inert atmosphere. Each complex includes unshielded repair areas, test laboratories, equipment rooms, storage areas, offices, and other facilities. The HFEF provides the operational support to EBR-II, and the capability to examine and reconstitute experimental subassemblies irradiated in EBR-II for breeder reactor programs on fuels and materials. HFEF will be used for FFTF post irradiation examinations pending completion of the fuels and materials examination facility at the FFTF site.

- The Zero Power Plutonium Reactor (ZPPR) is operated by ANL at the INEL in Idaho with capacity for experimental reactor assemblies up to 14′ x 14′ x 10′. ZPPR is the largest and best suited critical facility in the world for accurately modelling large fast reactors. Extensive benchmark and mockup experiments needed for both homogeneous and heterogeneous CRBR core designs are nearly complete. Further benchmark and mockup experiments will be needed at ZPPR during the 1980s to guide and confirm the designs of large-scale developmental cores which may incorporate such additional features as heterogeneous configuration, advanced fuels, and long-lived capabilities. ZPPR is equipped with an automated fuel loading machine, which supplants manual loading/unloading operations and thereby minimizes personnel exposure to radiation in accordance with the DOE policy.

- The Transient Test Reactor facility (TREAT) is an air-cooled, thermal, heterogeneous reactor located at the ANL-West site and operated by ANL. TREAT currently provides the capability to irradiate reactor fuels and structural materials under conditions simulating various types of nuclear excursions and transient undercooling situations. It is also available for limited neutron radiography. The facility is being modified to permit transient testing of larger safety experiments in a more prototypic fast reactor environment.

- The Zero Power Reactors 6 and 9 (ZPR-6 and ZPR-9) are located and maintained at ANL in Illinois (ANL-East). As examples of their many uses, a series of critical experiments culminating in the engineering mockup criticals which established the FFTF core design were performed on ZPR-9. ZPR-9 and ZPR-6 more recently enabled safety test facility criticals, and special investigation measurements intended to resolve persistent discrepancies which appear in the analyses of ZPPR experiments. ZPR-9 is currently in standby and operation at ZPR-6 will be deferred during FY 1982.

The FY 1982 request for ETEC provides for operations and maintenance labor, materials, and services to support a moderate level of facility operation and testing.

The principal facilities to be operated are:

- The Sodium Pump Test facility - This large flow and transient test loop which is being upgraded in two stages to test larger pumps, will have the 34,000 gpm CRBR prototype double suction pump installed, and system checkout will be performed and a very limited performance test will be completed.

- The Sodium Components Test installation - A major upgrade of this heat transfer and flow test facility has been completed, raising its capacity to 70 MW (thermal) from the original 35 MW. The installation of the 117 MW CRBR hockey stick prototype steam generator will be completed, and system checkout will be performed. A very limited performance test of the steam generator will be initiated.

- The Large Leak Test Rig - This facility simulates large leaks in LMFBR steam generators, and measures the effects of the ensuing sodium-water reaction on a model of a heat transport system. Tests on a full length, part-scale diameter model steam generator were completed in previous years. In FY 1982, sodium-water reaction testing on a full diameter (CRBR size) steam generator model will be concluded.

- The Thermal Transient facility - Using inert gas at very high velocities to simulate liquid metal heat transfer, this facility can operate quickly, inexpensively, and safely to perform component tests to destruction by means of vigorous changes in temperature. Testing on pipe sections and steam generator bimetallic and trimetallic transition joints will be concluded in FY 1982.

- The Small Components Test Loop - This multipurpose sodium flow and transient test loop is the workhorse of the ETEC facilities for small component testing. Testing will be conducted on an alternate primary pump model.

ETEC has a number of other, smaller test facilities, which perform water flow, static sodium, and other forms of testing. A water test will be conducted on a one-fifth scale model of an alternate primary sodium pump, and limited test programs will continue on flowmeters, heaters, strain gages, and level, pressure and proximity measuring devices.

In FY 1981, General Support efforts included the assignment of contractor personnel to Japan in support of the component development program, conceptual design efforts, and general program support efforts by major LMFBR laboratories and contractors. These efforts will continue in FY 1982.

The operating funds for HEDL will provide minimum support for design and construction activities for the Fuels And Materials Examination Facility (FMEF), the Fuel Storage Facility (FSF), and the Maintenance And Storage Facility (MASF). The funds will provide for the operation of the sodium and hydro-mechanical test facilities. In addition, the funds will be used to support personnel, normal maintenance and materials.

HEDL safeguards operating funds will be used to operate systems to control, account for, report, measure, and inventory Special Nuclear Material; and conduct studies and develop new systems to improve these capabilities.

The FSF, located adjacent to the FFTF, will store and remove decay heat from a 5 year supply of irradiated FFTF driver fuel and reactor experiments. FSF construction is complete and the facility is undergoing checkout in preparation for achieving operating status in FY 1982.

The MASF, also located adjacent to the FFTF, will provide for sodium removal, decontamination, repair, storage and staging of large components for the FFTF and related breeder reactor program facilities. Construction of the MASF is scheduled for completion in the second quarter of FY 1982.

The FMEF combines the major functions of examination of FFTF fuel and test assemblies and the development of technology for proliferation resistant fuel fabrication. The construction is scheduled for completion in the second quarter of FY 1984. The Administration plans to increase the size of the current FMEF building design to provide space for the secure Automated Fuel Fabrication line. A FY 1981 supplemental appropriation of $18 million is being requested to accomplish this effort.

The INEL facilities operating budget provides for planned completion of the Sodium Loop Safety Facility (SLSF) safety test series in the Engineering Test Reactor (ETR) under the LMFBR safety program and for the initiation of those activities required to place ETR in a shutdown (wet standby) condition, to be completed in FY 1983.

## Supporting Programs

Safeguards and program assurance activity provides for physical security systems and methods of material control and accountability in order to provide an integrated safeguards system for DOE facilities which acquire, use, store and dispose of special nuclear materials. Line item construction efforts to upgrade laboratory safeguards and security and funded in prior years are currently in progress. The upgrades at ANL are to be completed in FY 1981; those at HEDL and at INEL (Test Reactor Area) are to be completed in FY 1982. The FY 1982 funding request will provide for safeguards and security operations at ANL and HEDL; INEL Test Reactor Area safeguards and security operations are provided for indirectly through overhead support.

Program assurance includes operational safety, quality assurance and standards. These functions help assure that civilian nuclear reactor projects and waste management projects within the nuclear energy sector are carried out in a safe, reliable, and effective manner. In FY 1981 safety assessments and appraisals, quality assurance audits and training development, and standards development activities are being performed. These activities will be continued in FY 1982. The FY 1982 request will provide for continuation of supporting contractor activities at HEDL, ANL, and at Oak Ridge National Laboratory (ORNL).

Inventory efforts in FY 1981 include the procurement of fuel and special process spares for the FFTF program offset by the withdrawal from inventory of fuel for the EBR-II. If inventory transactions are required in FY 1982, program funding will be transferred into this account from the applicable program.

## FUEL CYCLE RESEARCH AND DEVELOPMENT

The fuel cycle program consists of fuel reprocessing technology and the Light Water Breeder Reactor, Proof-of-breeding (LWBR-POB) support activities. The budget request for these activities for FY 1982 is $26.1 million in budget authority, compared to an appropriated level of $47.5 million in FY 1981.

## Fuel Reprocessing Technology

Support for the development and demonstration of fuel reprocessing technology is a necessary element in closing the fuel cycle for the breeder reactor and a logical first step in demonstrating a technical solution to the Waste Management problem. The objective of the program is the development and demonstration of adequate technology for reprocessing both fast breeder and light water reactor fuels. The program goal is a demonstrated technology which, when applied, will reduce occupational exposure, improve environmental protection, enhance operational safety and reliability and minimize proliferation risks.

## LMFBR Fuel Reprocessing

The program includes the development and cold testing of engineering scale reprocessing equipment components, remote sampling devices, off-gas management systems, process control and safeguards instrumentation and overall facility conceptual design. The concept of total remote maintenance coupled with advanced process instrumentation (REMOTEX) is one of the bases for meeting the objective of the program.

In fiscal year 1981 the testing of engineering-scale equipment as individual components continued while the construction of the Integrated Equipment Test (IET) Facility at Oak Ridge, Tennessee, was progressing. The conceptual design of the Hot Experimental Facility (HEF) was completed and a design report issued. Such a and safeguards instrumentation and overall facility conceptual design. The concept of total remote maintenance coupled with advanced process instrumentation (REMOTEX) is one of the bases for meeting the objective of the program.

In fiscal year 1981 the testing of engineering-scale equipment as individual components continued while the construction of the Integrated Equipment Test (IET) Facility at Oak Ridge, Tennessee, was progressing. The conceptual design of the Hot Experimental Facility (HEF) was completed and a design report issued. Such a facility would provide for the demonstration of fast breeder fuel reprocessing technology using fully irradiated breeder fuels, initially from the Fast Flux Test Facility located in Richland, Washington.

In fiscal year 1982, the IET will be completed and limited testing initiated of equipment components integrated into process systems. Testing will be initiated on the eight stage centrifugal contactor designed by Argonne National Laboratory and constructed at the Savannah River Laboratory. The remotely operable, remotely maintainable rotary dissolver will also be completed in FY 1982 and initial testing begun. Work will continue on laboratory and hot cell testing for the verification of flowsheet performance with respect to fissile products recovery and fission product decontamination.

The accomplishment of the fuel reprocessing demonstration and the plutonium supply mission are essential ingredients of the overall strategy to deploy the breeder reactor to achieve a safe, reliable and secure supply of economical energy.

## Light Water Breeder Reactor, Proof-of Breeding (LWBR-POB)

The LWBR-POB analytical support project provides analytical chemistry support to the Naval Reactors (NR) Division's program to develop a Water Cooled Breeder (WCB) reactor. The project is scheduled for completion in FY 1985.

The objective of this project is to destructively analyze select fuel segments to provide NR with precision analytical chemical data. NR will use these data to calibrate their nondestructive assay gauge which will in turn permit them to determine the amount of fissile material (uranium-233) bred in the Shippingport reactor.

In FY 1981, equipment development, design and installation continued. This included completion of design of the full scale single rod fuel shear, initiation of design of the waste/scrap calcination system and installation of the Single Unit Dissolver System.

In FY 1982, equipment installation in hot cells at Argonne National Laboratory will be completed and personnel staffing and training will be nearing completion. It is anticipated that irradiated Shippingport fuel will be received starting in December 1982, and chemical analysis will be conducted by ANL in FY 1983 and FY 1984.

Mrs. BOUQUARD. That's a brilliant statement. We certainly appreciate your input, Dr. Dillon.

I would like to recognize, at this time, our ranking Republican member on the committee, the Honorable Manuel Lujan.

Do you have a statement you would like to make at this time?

Mr. LUJAN. I don't have a statement, but I would like to say that that's probably one of the more comprehensive statements we have seen. Together with the viewgraphs, it gives us a good understanding of what you're doing.

We've all been wondering what you were up to.

Thank you.

Mrs. BOUQUARD. I think you would also like to join with me in welcoming out students from North Carolina State, with Dr. Cockrell, who are here and participating in our hearing this afternoon.

Dr. Dillon, if we begin design of a large development plant in the next couple of years, the design teams of this effort will probably be winding down in the beginning of the 1990's. And, in keeping this design capability intact, as a major program goal, it would seem a decision to build the first commercial plant would have to be made about 1990.

Do you agree with this assessment?

And if you do, what are its implications for supporting the program elements, such as our fuel cycle R. & D.?

Dr. DILLON. I certainly think the design activities on the large plant will be completed sometime in the early part of 1990.

The implications, in terms of when it's necessary to commercialize breeder reactors, though, I don't think would have to follow directly out of that.

The process that we envision is a complex one, and I don't think it will be so simple that we will immediately launch on the construction of commercial breeder reactors.

There will have to be a lot of careful work done first, by reactor manufacturers and by utilities, in defining exactly what are the characteristics and performance specifications that they will demand for the breeder reactors that they will use in the utility grid.

I think there will be a long period—perhaps a very substantial period—where there will be proprietary improvements that will bring down the capital costs of breeder reactors. This will be the actual process that will take place in the private sector, and will lead to breeders coming into commercial reality.

So, I don't see the inevitable consequence of completing design activities on the large plant to mean that we would have to commercialize the breeders in the mid-1990's.

Mrs. **Bouquard**. What I was getting at the implications of supporting a program such as our fuel cycle R. & D.

Dr. **Dillon**. Some of the program elements like fuel cycle R. & D. will probably be phased to support a Hot Experimental Facility, something of the type that I showed you in the conceptual design picture. I think we would want to time that facility so that it could receive the spent fuel discharges from a large plant. That particular activity we expect would continue through the early 1990's, probably until the latter part of the 1990's.

Mrs. **Bouquard**. Wouldn't an important element in keeping our design team together require our plant decisions be made in this time frame? You know, one of our key programs for the past 4 years has been keeping our design team together for CRBR even though we didn't break ground. We thought this was a major accomplishment. So I was referring to keeping our design team intact in this time frame.

Dr. **Dillon**. We would expect that the next step after the large plant would be a classical type of commercialization where the individual reactor manufacturers would take their part of the design team and begin to use that as a nucleus to create a comprehensive design team within their own firm, and that the activity that we envisioned at that time would be one whereby individual suppliers and individual utilities would begin to proceed with commercial activities regarding the development of breeder reactors rather than continuing a sequence of Government-sponsored plants.

Mrs. **Bouquard**. Along this line, Mr. Gates, to what extent is the administration looking for greater private funding for our nuclear R. & D. programs, and what Government incentives are being considered in looking for this private participation?

Mr. **Gates**. Madam Chairman, I believe the Government will undertake presently the determination of industry interest in the earlier phases of reprocessing light water reactor fuel. Of course, at this time I would not have any idea of the nature of the financial arrangements that might be made, but I do think that it would be a source of inquiry and investigation by the Government with industry to determine their degree of interest and to arrive at some kind of cost arrangements.

Mrs. **Bouquard**. Wouldn't this be in the category of R. & D. where the payoff is a long-term option? Secretary Edwards said we were going to——

Mr. **Gates**. I think I know what you are asking, Madam Chairman—Mr. Edwards stated that the emphasis of the Department will be on the long-term high-risk program as opposed to the short-term low-risk. I believe, indeed, that is why we on the nuclear energy side of the Agency were fortunate enough to realize an appreciation in our request in fiscal 1982 funds under the current administration as opposed to the last administration. That philosophy has been very helpful to us.

Mrs. **Bouquard**. For that we are grateful.

Mr. Lujan?

**Mr. Lujan.** Thank you, Madam Chairman. Did you say you had to license Clinch River before you begin actual construction?

**Dr. Dillon.** The Energy Reorganization Act of 1978 requires that any liquid metal plant built by the Department of Energy that puts power on to an electric utility grid or that is used for demonstration of commercial application of technology would have to be licensed.

**Mr. Lujan.** That's kind of unusual, isn't it, for a research project?

**Mr. Gates.** I believe that decision hasn't yet totally been made, Mr. Lujan. You know there was a lot of work accomplished between the Department of Energy and the NRC in the years preceding 1977 relative to evaluation of the CRBR. I just hope that what has been accomplished will not be lost. We are presently seeing if NRC cannot reestablish the capability that they once had in progressing with us on evaluations of the Clinch River breeder reactor. Whether or not it's going to come to a formal licensing process or not, I don't know.

**Mr. Lujan.** No other reactor that was built on a research basis was licensed?

**Mr. Gates.** As a general principle, the Department espouses the philosophy that anything associated with national security programs, defense programs, and those activities in an R. & D. mode should not require formal NRC licensing.

**Mr. Lujan.** The Clinch River reactor is what--360 megawatts?

**Dr. Dillon.** 375 megawatts.

**Mr. Lujan.** On a scale up to——

**Dr. Dillon.** About 1,000 megawatts.

**Mr. Lujan.** And then commercialization?

**Dr. Dillon.** The commercial size would be somewhat larger. But the components, the main technology, would be at or very close to what would be in the 1,000 megawatt developmental package.

**Mr. Lujan.** So if you're talking about CRBR actually producing electricity in 1990, that's if you don't get mixed up with the NRC, I suppose, it would be 1990. But if you're talking about producing electricity in 1990, when are you talking about producing electricity at the demo plant?

**Dr. Dillon.** We haven't actually established the firm schedule. We hope before the year 2000, maybe in the mid-1990's.

**Mr. Lujan.** In relation to what Mrs. Bouquard was saying, do you plan to start A. & E. work on the——

**Dr. Dillon.** We would like to start some of the design activities in fiscal 1982.

**Mr. Lujan.** When you started off, Clinch River was going to be what—$500 million?

**Mr. Caffey.** Mr. Lujan, when it was first authorized, it was to be an estimated cost of $699 million.

**Mr. Lujan.** It's not decreasing then. What's the estimate now for the demo plant?

**Dr. Dillon.** We'll be submitting that at the end of the month. It will be about a $3.5 billion in current dollars. That hasn't been laid out in terms of the schedule.

Mr. LUJAN. If you were relating that $699 million to today's dollars, what would it be? It wouldn't have grown to $3 billion, would it, from $699 million, just on the basis of inflation?

Dr. DILLON. Not just on the basis of the escalation alone, no.

Mr. LUJAN. What has accounted for it? I'm very concerned about that. Almost any project that we go into just escalates so fast, I'm often afraid to vote an authorization for something, regardless of what the program includes. The food stamp program or Clinch River program seems to just go up so high.

Dr. DILLON. I do think in many cases in the past the initial cost estimates haven't been as refined and sophisticated as the techniques that we use now. I think the cost estimation procedure that is now being used to get cost estimates for the large plant is considerably more reliable and advanced than the one we used for Clinch River.

But I think any time a project—a large project like Clinch River—experiences delays, there is a tremendous cost impact associated with that.

Mr. LUJAN. But the other side of it is, these delays have been helpful in what you've learned, the changes that you've made.

Dr. DILLON. During these delays we were able to learn, but in no way to justify, the enormous cost associated with the extension, both in terms of dollars and in terms of reduced programmatic value.

Mr. LUJAN. A CRBR is substantially different today from what it was when?

Mr. GATES. 1969?

Mr. LUJAN. 1969.

Dr. DILLON. It's been significantly improved since then. On the other hand, if we had been able to proceed expeditiously with the project, project costs would have been significantly lower, and we would have had a stronger programmatic position.

Mr. LUJAN. What about the whole question of reprocessing? Obviously you're going to need a facility to do that. Is that running hand in hand with moving ahead with the CRBR? Or is that something waiting for the future?

Dr. DILLON. Reprocessing is absolutely vital for the long term future of nuclear power. As I said, it's the key.

Mr. LUJAN. I understand that, but I'm talking specifically. There would be some difference, I would imagine, between the reprocessing for a light water reactor and the reprocessing for a breeder.

Dr. DILLON. That's true. There is a substantial difference between them.

Mr. LUJAN. And is that moving ahead and keeping up——

Mr. GATES. I think that's one of the things we've got to be exceedingly careful about in the next few years. I don't think it's any secret, Mr. Lujan, we're hoping to acquire Barnwell in order to institute a reprocessing capability.

Mr. LUJAN. I still have those hopes.

Mr. GATES. I'm sure you understand, under the constraints of the budgetary tightening, that not everything that was desired could be acquired, and that was one of those things that we were unable to consummate.

Mr. LUJAN. I was thinking mostly in terms of research for the breeders, that we would have to develop some new technology to do it. If that is moving along—or are we going to come to the time when we have the breeder online, and then we find ourselves in the same situation that we find ourselves today with reprocessing, with waste management, with all of the problems?

Dr. DILLON. Absolutely. I couldn't agree more that the vital part of our strategy is to get ourselves to a position where we can expect the forces of the private sector to take up development of the breeder. We feel one of the prerequisites for that will be to have the reprocessing technology in hand.

Mr. LUJAN. Do we have money in there for that?

Dr. DILLON. It's in a very early stage. We have technology money, about $26 million. It's doing that work at the Oak Ridge facility that I talked about. It's cold testing. We will be working on that for some years and will eventually make a move to do a hot experiment test—test it with actual hot breeder fuels. And that will be more costly.

We do have a program now—it's an absolutely vital program that deals with those long leadtimes and reprocessing technologies that will be so important.

Mr. LUJAN. Thank you, Madam Chairman.

Mrs. BOUQUARD. Mr. Wolpe?

Mr. WOLPE. Thank you, Madam Chairman. Let me just take a moment to welcome Dr. Cockrell and 15 students from North Carolina State who I understand are in the audience and who are studying nuclear engineering. We welcome you to the proceedings today.

I would like to ask a few questions at this point with reference to the Clinch River breeder project. I must say at the outset that I do so with considerable reticence. It's not very easy to differ with our chairman. There is no one who's been a more effective advocate on behalf of the Clinch River program, an effort that's been made over the years, and the fact that this is still in the budget is very largely attributable to her effort. So I do so very reluctantly.

Mrs. BOUQUARD. I appreciate the confidence of my colleague.

Mr. WOLPE. This may well be another losing cause, but be that as it may, I do have some concerns with respect to that particular project, and I would like to try to lay out some of them.

I would like to begin by reading from an analysis prepared some time ago. This is a quotation:

> Until a few months ago I assumed the Clinch River Breeder Project was a good idea. It promised vast amounts of energy free from foreign control. But after a careful, indepth review of the economics of the project, I have come to the conclusion that it is totally incompatible with our free market approach to energy policy. The case for a Clinch River project and early breeder commercialization has been constructed almost without reference to the principles that we applied in the earlier energy debate.
>
> It ignores the dynamic resource adjustment process that will take place in the energy market during the next three decades. As a result, it overstates the future demand for electric power and understates the expanded supply of uranium that will be generated by higher prices. This lack of market reference in the case of the breeder obscures the clear cost advantage of sticking with conventional nuclear power over the next 30 years. The breeder cannot compete with existing nuclear technologies within the time frame contemplated by its advocates without continuing massive subsidies.

And then let me read another portion by the same author:

> Development of energy technology options should not be confused with their marketing and commercial introduction. An essential principle of the market approach to energy policy is that when this stage of commercialization or near commercialization is reached, the market choice mechanism must take over and development subsidies must largely end. Therefore, the only justification for any continued funding of a Clinch River project is the hard economic judgment that under foreseeable conditions the market will select a breeder during the 1990's at the lowest cost form—rather as the lowest cost form of nuclear electric power production.
>
> Advocates of the Clinch River project have recently shifted their justification in an attempt to avoid this crucial test and are softpeddling the former argument that Clinch River is the first stage in an integrated commercialization program, but even a cursory review of the nature and scope of the timetable proposed by the science committee demonstrates the Clinch River project cannot be severed from the overall timetable for early commercialization.

And, finally, there's this portion of the analysis:

> The notion that after the Government and private firms have invested billions of dollars in developing a commercial breeder industry infrastructure, it was on how it would be easy to make a decision on commercialization is absurb. All of the expenditures on the project and its infrastructure will have become sunk investments. It will make no sense to write off all of this investment and put the breeder reactor on the shelf for two or three decades until economic conditions become more favorable should that be the conclusion of the Clinch River test.

First—is that a familiar analysis?

Mr. DILLON. Yes, sir.

Mr. WOLPE. You're aware then that it was prepared by David Stockman, the Office of Management and Budget in 1977.

I would like, Madam Chairman, if I may, to request that the full statement of Mr. Stockman entitled "The Market Case Against the Clinch River Breeder Project" be entered into the record at this point.

Mrs. BOUQUARD. Without objection, it will be made a part of the record. I might add it's a shame that Mr. Stockman cannot be here to defend his statement today.

Mr. WOLPE. I will welcome that opportunity to have him present. Perhaps we could invite him.

Mrs. BOUQUARD. I was very happy that he did include funding for the breeder reactor in his budget proposal. Please proceed.

[Mr. Stockman's statement referred to follows:]

# THE MARKET CASE AGAINST THE CLINCH RIVER BREEDER PROJECT

## I. Uranium Supply, Demand for Electricity, and Power Costs: Two Nuclear Technologies in Competition.

The issue of whether to continue heavy federal subsidies to the Clinch River project is fundamentally a question of energy costs, not one of quantity or supply adequacy. Clearly, we must make large additions to our electrical generating capacity between now and early in the next century. Due to dwindling fossil fuel supplies, an increasing share of this additional capacity must be nuclear. The market case against early breeder commercialization, as distinguished from the anti-growth and anti-nuclear arguments, does not deny either of these propositions.

But it does focus on a very specific and important question regarding the appropriate choice of nuclear technologies and the timing of their introduction into the commercial market. The question is, within the time frame under consideration-- roughly the period from 1990 to 2010/15-- which nuclear technology offers the prospect of adequate electric power production at the lowest cost: the conventional light-water cooled reactor or the proposed breeder-plutonium fuel cycle?

Either of these nuclear power variants can fill our electric needs. The question presented by the Brown amendment is which will be the best bargain for the economy, electric customers, and the Federal treasury.

This question cannot be answered apart from the dynamics of the marketplace and its complex interaction of electric power demand, uranium ore supply, and the comparative capital and fuel cycle costs of the two technologies.

No one has seriously argued that the breeder is competitive or ought to be added to our electric energy supply system so long as there is an adequate supply of low-cost uranium. Current figures indicate that the capital cost of the breeder will be from $100 to $200 greater per kilowatt of capacity than for conventional light-water reactors. Similarly, at current uranium prices, the once-through fuel cycle of the conventional reactor is also cheaper due to the high cost of separating, reprocessing, and refabricating spent reactor fuel, as required by the breeder.

However, at such time as our supply of low-cost uranium is depleted and the price rises to levels perhaps three or four times above historic uranium prices, the comparative economics change. The breeder fuel cycle becomes cheaper because it does not require fresh uranium ore. Eventually, these fuel cycle savings more than off-set the higher capital costs of the more complex breeder reactor design and technology. Under these conditions the breeder variant would displace the light water reactor as the lowest cost source of nuclear electric power.

In a normal product market, the interaction of supply and demand would determine this threshold point, and thereby determine whether 1990, 2020, or any point in between, is the appropriate date for the introduction of the commercial breeder. However, the market for advanced nuclear electric technologies (and indeed advanced energy technologies of all types) is heavily influenced by extensive Federal involvement in research, development, and demonstration.

In the present case, this involvement is appropriate due to the unusual national security implications of civilian nuclear power and due to the clear national economic benefits which result from public financing of research and development activities that would have prohibitively long pay-back periods in the private sector, especially in the risk-averting utility industry.

But development of energy technology options should not be confused with their marketing and commercial introduction. An essential principle of the market approach to energy policy is that when the stage of commercialization or near commercialization is reached, the market choice mechanism must take over and development subsidies must largely end. Therefore, the only justification for any continued funding of the Clinch River project is the hard economic judgment that under foreseeable conditions, the market would select the breeder during the 1990's as the lowest-cost form of nuclear electric power production.

Advocates of the Clinch River project have recently shifted their justification in an attempt to avoid this crucial test, and are soft-pedalling the former argument that Clinch River is the first stage in an integrated commercialization program. But even a cursory review of the nature and scope of the timetable proposed by the Science Committee demonstrates that the Clinch River Project cannot be severed from the overall timetable for early commercialization.

The new argument is that the Clinch River project offers a kind of energy "insurance policy," or a scaled-up R & D option on which a commercialization choice can be made in the late 1980's--after the project is in operation. But this argument ignores economic and political realities. The Clinch River project will cost at least $2.7 billion. In conjunction with the other elements of the breeder development program, it will generate a vast industrial support and supply infrastructure among private companies engaged in all phases of reactor design, component manufacture, and plutonium fuel cycle support. The development of this infrastructure is in fact one of the central goals of the project.

The notion that after the government and private firms have invested billions of dollars in developing a commercial breeder industry infrastructure, it will somehow be easier to make a decision on commercialization is absurd. All of the expenditures on the project and its infrastructure will have become sunk investments. It would make no sense to write off all of this investment and put the breeder reactor on the shelf for two or three decades until economic conditions become more favorable, should that be the conclusion of the Clinch River test. What will happen is that the breeder will develop still greater institutional momentum. As difficult as the decision to defer breeder commercialization is today in the face of clear and convincing evidence, it will become still more difficult at the so-called "commercialization decision date" in the 1980's.

What about the "insurance policy" argument? It may seem attractive to support the Clinch River project despite its very unfavorable economics against the risk of unpredicted deterioration in the world uranium market. But uranium is not the only fuel source facing the prospect of depletion of low-cost reserves. Supply uncertainties are at least as strong for conventional sources of natural gas and crude oil. If we adopt the "insurance policy" rationale, the Federal government should make a commitment to very heavy subsidies for commercial scale synthetic crude, oil shale, geopressurized gas, and coal gasification plants as well--just to provide an "insurance policy" for other vital energy sources. This kind of logic obviously leads very rapidly to a non-market based energy supply system, something that I fervently hope is not our goal.

In light of these considerations, it is clear that the time to make the choice between accelerated or deferred commercialization of the breeder is now. The following sections demonstrate quite clearly that market conditions will not be conducive to breeder introduction until well into the next century.

## II. There Is No Such Thing As Free Energy.

The preceding makes clear that the breeder is an advanced technological variant of current reactor and fuel cycle design, not the energy equivalent of a perpetual motion machine. Contrary to the popular image, it does not "breed" more energy than it consumes; rather, the breeder facilitates a more complete extraction or recovery of the energy potential of uranium ore than is possible with current technology. This enhanced recovery, however, comes at a substantial premium in reactor capital investment and fuel reprocessing facilities.

For this reason, the widely advertised fact that the enrichment tailings left over from the conventional nuclear process contain the energy equivalent of a trillion barrels of oil is of little significance divorced from the context of economic costs. For one thing, this huge, dramatic number represents electric-generation input equivalents, not end-use energy available to the economy. Given the inherent thermal conversion inefficiency of electric power generation, the end-use value is something in the order of only 300 billion barrels of oil equivalent.

More importantly, incomplete energy recovery from fuel resources is by no means unique to the uranium 235 fueled light water reactor; the extraction and conversion process for nearly every fuel in use in the economy today exhibits the same pattern.

On the average, almost two-thirds of the crude oil in a given reservoir is left in the ground because the costs of a higher rate of recovery are prohibitive. In fact, since the beginning of the petroleum age in the United States, nearly 300 billion barrels of oil have been left in the ground due to the economic limits of recovery.

Similarly, until recently most U.S. coal seams have been deep-mined, yet the typical "room and pillar" method of extraction has left considerably more than half of the available coal behind. The amount of energy in this unrecovered coal is the equivalent of another 300 billion barrels of oil.

A proposal to launch a massive Federal subsidy program to re-open abandoned mines and wells, or to encourage much higher rates of recovery from currently producing properties, would not be given serious consideration at the present time. Yet the much bally-hooed stored uranium tailings are no different in principle. The desirability of enhanced BTU recovery from any fuel is essentially a matter for the market to decide; physical potential is a thoroughly inadequate justification for a large subsidy program.

## III. Future Electric Power Demand and Market Adjustment.

The linchpin in the case for subsidized breeder commercialization has been enormous projected increases in electric power demand during the next three decades. As recently as 1974, for example, the ERDA mid-case estimate showed a need for 2,200 gigawatts of generating capacity by the year 2000--a figure which represents generating capacity more than four times greater than available today.

Under this demand scenario, a minimum of 1,000 gigawatts of nuclear capacity would have been absolutely essential (this compares with 40 gigawatts of nuclear capacity on-line at present). Nevertheless, even at this high level of nuclear supply, coal-steam capacity would have had to increase four-fold to make up the difference. Obviously, under these electric demand conditions, known and even speculative supplies of low-cost uranium would have been inadequate, making early breeder commercialization imperative.

In truth, however, these demand projections represent an inexcuseable ignorance of market dynamics. Rather than being sophisticated economic projections, these numbers were merely mechanical extrapolations of the electric power consumption growth rate that had prevailed for the previous decade or so, about seven percent per year.

Yet this high electric consumption growth rate--nearly double the average growth in GNP--was made possible by a single key economic factor that even in the early 1970's should not have been viewed as indefinitely sustainable: a steadily declining real price of electric power.

Between 1945 and 1970, for example, the constant dollar cost of residential electricity dropped from 11 cents per kilowatt hour to only 2.5 cents per kilowatt hour; similarly, industrial rates were reduced by more than one-half during the same period. The result of this unique combination of steeply declining unit prices and rapidly growing total consumption was that the share of GNP devoted to purchased electricity remained almost constant at 2 percent during the entire post-war period.

It is clear today that declining real prices for any energy source, including electricity, are a thing of the past. Indeed, average electricity rates in constant dollar terms have already increased by 34 percent since 1972.

Due to huge additional costs for environmental controls, rising costs of utility financing and capital, and sharply increasing utility fuel costs, a substantial continuing rise in real electric rates over the next 20 or 30 years is highly probable. Indeed, one recent study by ERDA's Institute for Energy Analysis indicated that real electricity prices will increase by more than 60 percent by the year 2,000.

Yet assuming a seven percent growth rate in electrical consumption (as per earlier ERDA demand studies) in combination with the undeniable prospect of something in the order of a 50-60 percent increase in electric rates (as per recent ERDA price studies) produces an entirely absurd proposition: namely, that the fraction of GNP devoted to the purchase of electric power would jump from its historic 2 percent level to more than 15 percent! Even at a more modest 5 percent annual consumption growth rate, the mathematical outcome is nearly a 10 percent share of GNP going to electrical purchases.

There is little reason to believe that the economy would permit such a drastic shift in resource allocation to occur. The residential market, which has been a source of differentially high growth in recent decades, provides a good case in point.

This sector is now nearly saturated with basic appliances, as symbolized by the Census Bureau's decision to discontinue its questions on basic appliance ownership because levels have reached 99 percent. In addition, the stabilization of the population growth rate indicates a much lower rate of new household formation than in previous decades. There is also a strong prospect of large increases in household thermal efficiency in both space conditioning and appliance applications, spurred by mandatory efficiency standards, the likelihood of strong solar penetration, and of course simply by rising power rates. For these reasons it is probable that aggregate household consumption of central station power will grow very modestly, if at all, during the next few decades.

The process of factor substitution will greatly constrain the rate of industrial and commercial power growth as well. To take one specific instance, it is almost certain that the two and one-half decade long decline of industrial co-generation, during which co-generated power declined from almost 20 percent of industrial use to 10 percent, will be sharply reversed, thereby constraining demand for purchased central station power.

As a result, an average electrical consumption growth rate in the three percent range seems highly probable in the decades ahead. Even this would mean an increase in the central station electricity share of GNP to nearly 5 percent by the year 2,000, assuming a 60 percent increase in real prices.

Since the long-term growth rate for real GNP is roughly in the 3 percent range, this would imply a 1:1 growth ratio between electrical consumption and GNP, a sharp contrast with the 2:1 ratio implicit in the pro-breeder scenarios.

There is already strong evidence accumulating that this sharply reduced growth rate in central electric power is likely. During the last two years of strong economic recovery and high real GNP growth, electrical consumption has increased only at a 1:1 ratio with GNP. This contrasts markedly with the pattern during previous decades in which even strong cyclical recovery years exhibited electrical consumption growth rates far in excess of GNP.

## IV. Meeting Electric Demand Under a Realistic Market Scenario.

The foregoing considerations make clear that rather than in excess of 2,000 gigawatts of electric capacity by the turn of the century, the more probable estimate is in the range of 1,000 gigawatts (based on a three percent average growth rate instead of seven). On the basis of current trends, it is likely that even 350 gigawatts of nuclear electric capacity is an optimistic estimate of the nuclear share of this total capacity requirement.

Two strong considerations support this estimate. First, there is little reason to believe that there would be serious restraints on achieving roughly 650 gigawatts of non-nuclear capacity. Presently, for example, hydro-electric accounts for 65 gigawatts. The Interior Department projects that this will reach nearly 100 gigawatts by 1985. In addition, it is almost certain that a minimum of 5 percent of capacity will have to be fired with liquid or gaseous fuels (perhaps synthetics) because it is simply economically prohibitive to use large coal or nuclear fired plants for peak-shaving purposes.

This leaves a requirement for baseload coal capacity in the range of 500 gigawatts. Presently, there are 250 gigawatts of coal capacity in place. According to current surveys, another 100 gigawatts of coal capacity is either under construction or planned through 1985. Thus, over the remaining fifteen years of the century only another 150 gigawatts of capacity would be required, an average of 10 coal-fired plants per year.

These coal fired capacity estimates imply annual coal production of slightly over 1.2 billion tons per year, even after allowing for substantial increases in direct industrial use. Since the Carter Administration has targeted this production level for 1985--15 years earlier--there is little reason to think that there would be serious supply constraints.

The second reason to believe that nuclear capacity would not exceed 350 gigawatts under a realistic demand scenario is simply the lagging rate of light water nuclear plant additions in the past three years. The 350 gigawatt figure for the year 2,000 implies that 14 new 1,000 megawatt units will become operational during each of the next 22 years.

Yet in 1975, there were only two new orders for nuclear plants; in 1976 there were only three; and this year there have been none. Moreover, during the same period there have been 18 units cancelled representing nearly 20,000 megawatts of nuclear capacity. Compared to the 5,500 megawatts of new orders, this means that just since 1975 there has been a net decline of nearly 14,000 megawatts of nuclear capacity ordered for the 1980's.

Certainly it is to be hoped that Congress will act soon to streamline the present disasterously complicated and prolonged licensing process, and that the intense social and political opposition to nuclear power generation will be overcome. Nevertheless, the experience of the past few years makes clear that the required annual addition rate of 14 nuclear plants will be difficult to achieve, and that 350 gigawatts of nuclear capacity by the year 2000 is indeed a conservative reference target for analyzing uranium supply and prices.

## V. Uranium Supply and Prices: Bureaucratic vs. Market Perspective

The second critical question regarding early breeder commercialization concerns future prices and supplies of uranium ore. Specifically, is there likely to be a sufficient supply of low-cost uranium ore to support the lifetime requirements of 350 gigawatts of nuclear capacity, thus permitting a deferral of breeder commercialization program until after the turn of the century?

The answer to this question depends first of all upon future enrichment practices. Uranium oxide contains roughly .7 percent U-235, but the extent of enrichment extraction of this fissionable material can range from 57 percent (.3 tails assay), to between 87 and 100 percent

(.1- 0 tails assay). For this reason, projections of uranium oxide requirements are very sensitive to assumptions about enrichment methods and the tails assay.

Specifically, the lifetime requirements of the 350 gigawatts of nuclear capacity projected previously would be 2.5 million tons, assuming .3 tails; 2.2 million tons, assuming .2 tails; and 1.8 million tons, assuming .1 tails. The high tails assay thus produces uranium ore requirements nearly 40 percent greater than under the low assay.

Traditionally, U.S. enrichment facilities have operated at a .2 tails assay. But in 1973 this was temporarily increased to .3 in response to what appeared to be a growing shortage of enrichment capacity relative to projected rapid growth in the nuclear power market. The effect of this change was to increase the apparent uranium oxide requirements for current and planned light water reactors by 26 percent.

However, it is likely that the future trend will be toward increasing rather than declining extraction of fissionable material from our uranium supplies. The anticipated shortage of enrichment services capacity has become extremely unlikely because of the serious slowdown in reactor deployments and because of the active enrichment capacity expansion program now underway.

Another factor determining the level of extraction efficiency is the cost of enrichment services relative to the cost of uranium. As the price of raw uranium rises relative to the price of enrichment, the percentage of U-235 that can be economically extracted from raw ores increases. Thus even assuming that there are no breakthroughs in enrichment technology, the proportion of useable fuel that can be extracted from raw uranium will rise over the next decades.

The biggest potential increase in extraction efficiency will come from new technologies, however. These new processes promise to radically reduce the amount of U-235 left in the tailings. The most promising new technology from a theorectical standpoint is laser isotope separation. This process may be capable of extracting nearly 100 percent of the U-235 from uranium ore, thus vastly expanding the amount of fuel that could be produced from our uranium supplies. The tailings piles that breeder advocates point to as a huge potential source of energy could be used to produce fuel for light-water reactors if laser isotope separation becomes commercially viable.

Another promising variant in enrichment technology is the gas centrifuge. Current U.S. enrichment plants use immense quantities of electricity. When all three plants are operating at full capacity, they use nearly as much electricity as the entire state of Minnesota.

But because these plants had access to the very cheap electric power produced by the TVA, the cost of enrichment remained within reasonable limits. Now that even TVA power has become significantly more costly, less electricity-intensive enrichment technologies such as the centrifuge may be able to lower the cost of enrichment services. This will permit a higher rate of extraction.

Both of these new enrichment technologies are under intense development. The Administration requested more than $50 million in FY 1978 for advanced isotope separation techniques. A gas centrifuge plant is planned for construction within the next decade as an expansion of the Portsmouth, Ohio enrichment facility.

In light of these almost certain improvements in enrichment efficiency, it would be prudent to assume a maximum uranium oxide requirement of 2.0 to 2.2 million tons to meet the lifetime fuel needs of the 350 gigawatts of capacity projected above. It is necessary to make some very unreasonable and non-market oriented assumptions to show that uranium supplies in these magnitudes will not be available in the decades ahead.

Before proceeding to a discussion of current reserve estimates, two frequently encountered red herrings need to be disposed of. The first is that the current "proved" reserves of uranium only total 680,000 tons, or roughly one-third of the supply requirement indicated above.

However, the term "reserves" refers only to uranium resources that have been specifically located and delineated by drilling and other engineering techiques. Placing resources into this category thus requires mining companies to make substantial investments. These investments will obviously not be profitable unless these reserves can be produced in the relatively near future. Thus, the widely quoted reserve number actually represents a "production inventory" and has little to do with the potential resource base, the relevant concept for decision-making purposes.

The most apt analogy is the case of natural gas, for which proven reserves now stand at about 200 trillion cubic feet. Were this taken as the potential resource base and were production to continue at current rates we would reach absolute depletion in 1987. Even the most conservative analysts of the natural gas industry have not suggested this extreme possibility.

For one thing, natural gas, uranium and almost every other extractable resource has a clear "extension" pattern in which economically delineated reserve levels imply a somewhat fixed "new find" rate in adjacent deposits or reservoirs within prevailing price ranges. Current ERDA estimates put these uranium extension reserves, the most conservative category of resource base expansion, at 1.1 million tons. This, in combination with what has previously been termed the production inventory, amounts to nearly 1.8 million tons of known reserves, a figure nearly equal to the lifetime supply requirements given above.

Unfortunately, advocates of early breeder commercialization have used this figure (1.8 million tons) as the "prudent planning base" for calculation of breeder economics. But this is clearly a bureaucratic expedient rather than an economics based estimate, because it implies nearly a zero elasticity of supply beyond presently identified reserves. As will be shown more fully below, this assumption has even less credibility than that employed by proponents of continued regulation of natural gas.

The other item in the red herring category is the frequently recited fact that current spot market prices are in the $40 per pound range. But the spot market for uranium ore is extremely thin as most uranium is purchased under long-term contracts. As a result, the spot market price is highly volatile and can be highly affected by short-run demand conditions. In fact, the present high spot market price is a temporary aberration reflecting the surge in short-term demand induced by recent changes in ERDA enrichment practices, ERDA contracting procedures, and the massive abrogation of supply contracts by Westinghouse in late 1975.

A more reflective indicator of long-term price trends is the price for 1980's delivery contained in contracts written during the past year. These are almost entirely under $20 dollars per pound in real terms.

To return to the critical question of long-run supply it is clear as a matter of resource economics that the "prudent planning base" estimate of roughly 2 million tons used by breeder advocates is in fact, not only imprudent but actually nonsensical. By definition, proved and probable (extensions) reserves essentially represent past exploration activities. Therefore, to assume that this figure embodies the producible uranium supply for the indefinite future implies that either there will be absolutely no additional exploration for new uranium deposits in the coming decades or that the marginal cost of new reserves will escalate upward on nearly a vertical path.

The relatively brief history of the uranium mining industry offers no support whatever for either of these assumptions. Two trends tell the story. First, after the government-supported launching of the uranium mining industry in the early fifties, there was a persistent and steady decline in real prices--from $28 per pound in 1954 to less than $9 per pound in 1973. Yet despite this sharp drop in prices, exploration activity and production moved sharply upward. From 1950 to 1960 annual production increased nearly twenty-fold, and low-cost ($15 per pound and under) proved reserve levels rose from a negligible 3,000 tons to nearly 200,000 tons in 1960. By 1975 this category of the lowest cost reserves had again more than doubled to 430,000 tons. Resource base estimates (as distinguished from proved and probable reserves) were expanded in a similar manner.

Thus, in order to accept the prudent planning base estimates as the limit of future producible uranium supplies, it is necessary to assume that an industry that has been characterized by declining marginal costs, rapidly expanding reserve additions and drilling productivity rates that increased by nearly 6 percent annually for two decades will precipitously reverse course and careen down a path of sky-rocketing marginal costs and vanishing exploratory drilling productivity. The fact, however, is that even during the last three years of demand-induced market instability, drilling productivity in the low-cost reserve categories (under $30 per pound) has actually increased substantially, indicating continuity with past trends.

ERDA currently places the potential resource base, which includes both current reserves and future discoveries, at 3.7 million tons--a level nearly twice that necessary to sustain the 350 gigawatt scenario developed above. But these are of necessity extremely conservative figures because they embody geologic data gathered by an industry whose exploratory activities have been constrained by historic $10 per pound prices to the very lowest-cost uranium formations.

It is clear, however, that the breeder will not be competitive at a uranium price below $75 to $100 per pound. Under these conditions thereis little doubt that as long-term prices rise above the extremely low historic levels additional geologic data will be gathered permitting, a substantial expansion of the potential resource base, and therefore, future uranium reserves and production.

The final environmental impact staement on the breeder, for example, estimated that with the addition of new geologic data derived from increased search for higher-cost deposits, the potential resource base at prices of $50 per pound is nearly 9 million tons--over four times the level necessary to sustain the 350 gigawatt scenario.

## VI. The Magitude of the Cost Penalty for Breeders: Uncertain But Growing

The third reason why the breeder will not be commercially viable if introduced on the accelerated schedule proposed by the Science Committee is that the current projected cost differences between breeders and conventional reactors, both for the capital cost of the plant and for the fuel cycle facilities, are almost certain to widen in the years ahead.

When the Clinch River plant was originally proposed in the late 1960's, the projected cost of the plant was only $500 million, or about $1400 per kilowatt of generating capacity. By the time the project received its original authorization in 1973, the cost had gone to $690 million, or $2000 per kilowatt. Today, ERDA estimates a completion cost of $2.3 billion, or more than $7000 per kilowatt. Some experts have speculated that the cost may well go to $3 billion by the time construction is completed, since construction has not yet begun and experience with the Fast Flux Test Facility has been that most of the increases occur during construction.

At $7000 per kilowatt, Clinch River will cost more than ten times as much as current light water plants per unit of capacity. Of course, the cost of Clinch River includes many first-time exepnses, and other costs associated with the prototype status of the plant that make a direct comparison unjust. But this factor of ten represents the improvement that will have to be made in the economics of building breeders in order to make them competitive with light-water reactors. The increases in the cost of building Clinch River have been reflected in the increases in the estimated cost of later commercial breeders, however.

In a 1974 study supporting the rapid commercialization timetable, ERDA calculated that breeders would cost $100 per kilowatt more than conventional reactors at their 1995 commercial introduction date, and that this difference would be eliminated in thirteen years. The most recent ERDA projections show a cost difference of $145 per kilowatt initially, declining to $50 after thirteen years. This reduction in the cost of breeders is absolutely essential to the commercial success of the development effort on the present timetable, yet the history of the light-water reactor and the great unknowns in breeder and reprocessing technology make the likelihood of achieving cost reductions of the requisite magnitude almost nil.

As commercial technologies mature, process costs almost invariably decline. One notable exception to this rule has been the light-water cooled nuclear power reactor. By the end of 1967 after nearly ten years of commercial operation, the cost per kilowatt of LWR's had reached about $180 (1975 dollars). By 1973, the average cost had increased to $475 per kilowatt of capacity. Thus, even after setting aside the 34 percent increase in general price levels during this six year period, the real cost of light-water capacity rose nearly 200 percent.

The reason for the high rate of cost increases for nuclear plants was primarily regulatory and contractor design changes to meet safety and environmental problems, though of course some of it is attributable to the differentially high inflation rate of the construction industry in general. We simply did not know all therewas to know about these facilities, however, and consequently the regulatory mechanisms for internalizing costs in the plants resulted in the continual addition of new, unpredicted cost factors.

This process seems to be nearing an end for the light-water cooled reactor. The latest ERDA projections for the cost of building reactors for delivery in the early 1980's is $667 per kilowatt in 1976 dollars. This represents a rate of real increase of only about 2 to 3 percent annually, well below the levels of the previous decade. The implications of this stabilizing trend in the cost of conventional reactors for the competitive position of the breeder are enormous. The breeder has yet to go through any of the licensing and development processes that produced the great escalations in the cost of building light-water reactors. Yet the inherently greater technological complexity of of the breeder, the large number of materials and design engineering problems that remain unsolved and for which the basic research is not complete, all indicate a high probability that the cost difference between breeders and conventional reactors will widen, not narrow. Even on the basis of current knowledge, some experts have predicted a gap of over $200 per kilowatt well into the beginning of the next century if we proceed on the present timetable. At this level, uranium prices would have to be four times higher than current projections to make the breeder cost-competitive.

In addition to the risk of cost escalations from plant construction costs, the breeder also faces a great risk of escalations from increases in the cost of reprocessing. This is a risk that is completely absent from the once-through uranium fueled light-water reactor, and consequently a particularly sensitive part of the competitive equation.

Experience in reprocessing light-water fuel has been dismal. The private plant at Barnwell, South Carolina, originally projected to cost $250 million, will cost over $700 million--if it is ever completed. Its private sponsors have backed out of the project as uneconomical, and our now attempting to secure a huge federal subsidy to operate the plant as a "demonstration" project.

The likelihood that breeder fuel preprocessing will encounter even more serious problems than current reprocessing efforts is great, yet the cost figures used in the economic analyses relied upon by the backers of Clinch River have been extrapolations from experience with spent light-water reactor fuel. The accuracy of these extrapolations is open to serious question because of two major technical differences between reprocessing spent LWR fuel and reprocessing breeder fuel.

The plutonium content of spent breeder fuel will be approximately 40 times greater than that contained in spent LWR fuel. Thus a breeder fuel reprocessing facility will have to have contend with the safety problems associated with keeping this substantially larger proporation of plutonium from reforming into a critically-sized accumulation. In addition to the plutonium related problems, the breeder reprocessing plants will have to contend with fuel that has been irradiated at a higher temperature than present LWR fuel. This, combined with embrittlement caused by the higher neutron irradiation levels to which the breeder fuel has been exposed, will make the fuel more difficult to process. The West Germans have reported considerable difficulty in the handling of fuel from high temperature gas cooled reactors on an experimental basis, which may well be an indication of the problems that will develop with breeder fuel.

The bottom line, then is quite clear. Due to the inherent risk of nuclear technology, and to strong public attitudes (increasingly embodied in regulatory policy) insistent upon nearly absolute risk reduction, there is no basis for assuming "learning curve" cost reductions for new nuclear technologies.

The last decade of experience with the light-water reactor, which is an inherently less risky and less complex technology, has demonstrated this unequivocally. Therefore, the most reasonable assumption is that the currently projected capital cost and fuel cycle disadvantage of the breeder relative to conventional reactors will widen, rather than narrow. In that event, only drastic, highly improbable long-term changes in the uranium market would make the breeder a competitive option.

## VII. Conclusion

Under the following conditions the breeder will not be competitive until well into the next century:

1) Electric demand grows at only half the 1960's rate and the maximum share of year 2000 capacity required to be filled by nuclear-electric generation is on the order of 300-400 gigawatts;

2) There is a reasonably assured supply of at least 2.5 million tons of low-cost uranium ore (under $50 per pound);

3) Reactor cost differentials between the breeder and conventional plants are $100 or more, with similar differences in fuel cycle costs.

This analysis of the relevant economic markets makes clear that all of these conditions can be readily met. For that reason, early commercialization of the breeder will result in large economic losses to society in addition to a lengthy list of non-monetary risks in the safety, environmental and international relations-proliferation areas. Therefore, no further subsidization of the Clinch River project, an integral step in the early commercialization program, can be justified.

DAVE STOCKMAN
Member of Congress
September 17, 1977

Mr. WOLPE. What is your reaction to the analysis I just read?

Mr. DILLON. When then Congressman Stockman made that analysis, he was evaluating the Clinch River breeder project in the context of an overall plan that did call for very rapid, early commercial deployment of breeder reactors. The plan that's envisioned now doesn't link as strongly with commercial deployment. We feel, based on what we've learned ourselves over the past 4 years, and the strategies and approaches that are being taken in other countries, that we want to proceed with developing the basic and generic technology and engineering experience and then turn that base over to the private sector so that the free market mechanism can in fact determine the pace at which the breeder is commercially introduced in this country.

So the Clinch River breeder project is the same basic reactor design, but it has a different role to play in the overall program plan.

Mr. WOLPE. Perhaps I did not emphasize a portion of Mr. Stockman's analysis sufficiently. He indicated that back in 1977:

> Advocates of the Clinch River project have recently shifted their justification in an attempt to avoid this crucial test and are softpedaling the former argument that Clinch River is the first stage in the integrated commercialization program.

He went on to argue, in a portion I did not read a moment ago, that the new argument is:

> The Clinch River project offers a kind of energy insurance policy or scaled up R. & D. option in which commercialization choice can be made in the late 1980's after the project is in operation, but this argument ignores economic and political realities.
>
> The Clinch River project would cost at least $2.7 billion. In conjunction with the other elements of the breeder development program will generate a vast industrial support and supply infrastructure among private companies engaged in all phases of reactor design, component manufacture and plutonium fuel cycle support the development of this infrastructure is in fact one of the central goals of the project.

He was aware of the changing argument even back in 1977.

Mr. DILLON. There's no doubt that the developing of that infrastructure is an important part of the program goal, but the timing of it is such that we're not talking about it on commercial development in 1990?

The program we're developing will have built into it, turning over to the private sector in the latter part of this century, a basis on which they can proceed with the development based on private investments.

Mr. WOLPE. From my personal perspective, there's no question but that we ought to be about the business of basic research development and all sorts of alternative technologies for the future. The question is, we have limited Federal dollars. The question becomes what criteria are we going to employ to determine which investments have the greatest potential for displacing petroleum at the lowest possible costs, and it's in that context that I fail to frankly comprehend the thrust of an energy budget which argues, according to the program for economic recovery of the President, that one of the major criteria—one of the basic guidelines to be applied to reducing the budget this year was to be the application of sound economic criteria to subsidy programs.

We know from all of the data that has ever been released by the Department of Energy that we could be displacing petroleum far more quickly, for example, through some of the conservation initiatives, industrial conservation, residential conservation. Roughly, residential conservation can displace a barrel of petroleum equivalent for $6-$10 per barrel of oil. We know electricity in this country consumes only 9 percent of all of the petroleum that we are using, whereas 54 percent of all of the petroleum goes into transportation, another 18 percent into space heating, nonelectrical space heating.

I don't understand how one can end up with the Department of Energy research and development budget that has over two-thirds of the dollars allocated for the technologies that generate electricity when it is not electricity that is consuming the lion's share of our petroleum. How do you justify that on an economic basis?

Mr. **Gates**. May I comment, Mr. Wolpe?

Mr. **Wolpe**. Yes.

Mr. **Gates**. On your whole thesis, if I may. Of course, I don't know what Mr. Stockman's view is today, in 1981, as opposed to his view in 1977. Secretary Edwards certainly espouses the theory that you just referenced in that book before you; that is, one of the crucial decisions the Government must make today is what it will fund and what it will not fund. It is his belief that funding for the development of a fast breeder technology in the United States is one of those things which should be federally funded.

Now, with respect to the pros and cons of the CRBR, certainly in such a vital and important massive dollar program one will not find consensus across the board. I believe that the body of opinion that I support and that I think Secretary Edwards supports, is the philosophy that although the science is in hand, the engineering might not be: engineering is always one of the most difficult things to master in bringing forward a new technology.

Mr. **Wolpe**. I wanted to know when I asked why we were providing additional subsidy when we asked Mr. Edwards, it was before our committee not too long ago, why we were proposing to cut virtually the entire conservation and renewable energy effort within the Federal Government's budget, but increase the subsidies for utilities and nuclear power, his response—if that was based on economic criteria, he made no suggestion it was economic criteria, his response, the nuclear industry was in trouble, that's why we had to increase the subsidies.

Mr. **Gates**. I don't think there's any question the nuclear industry's in trouble, and part of the trouble has been——

Mr. **Wolpe**. In other words, we're bailing them out rather than applying economic criteria?

Mr. **Gates**. No, I don't think that a bailout can, in any fashion, be ascribed to the Federal Government's trying to revitalize the light water reactor industry or taking steps toward the development of a fast breeder technology.

With respect to your other observation, which is certainly true, that only 9 percent of our oil is utilized in the manufacture, if you will, of electricity, I think that production today amounts to something equal to almost 1½ million barrels of oil a day. That is about 25 percent or more of our current rate of imports of foreign oil. If we can enhance the amount of electricity that is generated by the nuclear program we're going to continue to save the imports of foreign oil, which is part of the objective.

Mr. Wolpe. No, no. But that totally misrepresents the issue. The issue is not whether or not nuclear power will displace some petroleum; that's not the question. The question is: What is the cheapest way of displacing petroleum most quickly? How do you do that most cheaply, and if you have—if you're looking at a situation in which 54 percent of all our petroleum is going to transportation, and a very small increment is going to electricity, that at least suggests to me that minimally we ought to be focusing some attention and resources on the transportation effect, whether it's alternative transportation fuels, mass transport, or what have you.

And I have difficulty understanding how we can cut the transportation budget, which is also cut in the President's program, and at the same time increase it on the electricity side.

Mr. Gates. I don't think there's any question but what a high percentage of all utilization is going to the transportation industry. It needs to be attacked. On the other hand, we're here developing options for energy supply and if I may extend again, sir, the comment about the amount of oil that we might save by increased generation of nuclear energy, there is a great amount of oil being utilized in commercial and home heating. Some three or four million barrels a day. If you add that, plus what one would save in electrical generation, you're getting almost two-thirds of our imported oil, which establishes one of our objectives.

Now, on the other hand, if it's a matter of economics of the cheapest electricity, there are as many studies balancing coal against nuclear as there are people in this room today. But, generally, I think the studies demonstrate that nuclear today, and in the future even more so, is cheaper than coal.

Mr. Dillon. That is the principal economic rationale for the program. In the strategic view, the reason that the breeder program has high priority is because of its capability of being a long-term secure domestic supply of energy that we can count on for thousands of years at a predictable economic cost. That's the incentive and the principal justification for the breeder program. Not the short term displacement of oil.

Mr. Wolpe. My time, I know, has been exhausted, but let me just indicate that my concern here is the application of a double standard, that we are not, in fact, and by Secretary Edwards' own admission, applying the kind of market criteria or the cost-effective criteria that the President indicated would be the basis for his decision. He said they would not be based upon political considerations. Only hard-nose cost effectiveness, and I have to tell you I don't see that reflected in the budget proposal before us.

Thank you, very much.

Mr. Forsythe?

Mr. Forsythe. Thank you, Madam Chairman. I'm sorry I missed your testimony, Dr. Dillon. I have a great interest in what we are talking about, and following my colleague and his concern about the shift from the conservation ethic to breeder reactor, for instance, I am wondering if really their play in that isn't based far more on market base conservation today than the need to do it as

Federal subsidies, again as part of trying to pull the Federal dollars out, how we can beat it some other way.

Decontrol of oil has certainly had a large measure, I think, on conservation on the use of oil, and we may not need to invest Federal dollars in subsidizing insulation and some of these other things today.

So I just offer that perhaps as a little piece of why I, with the administration and with you, believe that this breeder technology is very important, because we don't see the other technologies coming aboard in time that would see us through as early as the 20th century. I guess we all would love to see fusion here tomorrow, but that is kind of one of those things. Every year we look at it, it is 2 years more away. And I am not pulling back from wanting to see every nickel we can find to put in that, because I think that again is the way-out, long-term game we want to play.

I just had to offer maybe a little bit on the other side of the coin. Do you have any comment?

Dr. **Dillon**. First, thank you. Certainly the position you stated on conservation I have heard Secretary Edwards state often. He feels strongly that we will be able to use the market mechanism to make progress there. The long-term view of having energy—electrical energy—to fuel what I hope will be a healthy economic engine in this country is, I think, the principal rationale for the breeder program.

Mr. **Forsythe**. Thank you, Madam Chairman.

Mrs. **Bouquard**. Thank you very much, Mr. Forsythe.

Mr. Caffey, with the shift in emphasis in the breeder program toward the construction of our demonstration projects, what reductions in the breeder technology R. & D. and test facilities do you think will be achievable in 1982 and over the next several years?

Mr. **Caffey**. Madam Chairman, since I am down in Tennessee working on the project—the program development goes on at headquarters and I don't know what they may be thinking about it.

Mrs. **Bouquard**. Would you rather I refer that question to Dr. Dillon?

Dr. **Dillon**. Madam Chairman, I would like Bob Staker to elaborate a little bit in just a minute. But you know I did point out that we are operating the base program at an already reduced level and we plan on continuing to operate it at a reduced level. So we have already done some belt tightening and the elements in the program are all vital to support the plant projects, both the Clinch River and the large plant.

Bob?

## OFFICE OF REACTOR RESEARCH AND TECHNOLOGY

| | FY 1977 | FY 1982 EQUIVALENT* | FY 1982 PROPOSED | % CHANGE |
|---|---|---|---|---|
| BASE TECHNOLOGY TOTAL | 178.3 | 262.1 | 141.8 | (-46%) |
| COMPONENTS | 48.9 | 71.8 | 37.2 | (-48%) |
| FUELS/CORE DESIGN | 53.8 | 79.0 | 42.8 | (-45%) |
| SAFETY | 55.9 | 82.2 | 38.4 | (-53%) |
| PHYSICS | 9.9 | 14.7 | 10.9 | (-25%) |
| MATL/STRUCTURES | 10.3 | 15.14 | 12.5 | (-17%) |
| TEST FACILITIES | 65.3 | 96.0 | 79.0 | (-18%) |
| FFTF | 52.7 | 77.4 | 76.9 | ( -1%) |
| CAPITAL EQUIPMENT | 44.9 | 66.1 | 25.0 | (-62%) |
| CONSTRUCTION | 98.9 | 145.3 | 50.1 | (-66%) |

*EQUIVALENT ASSUMES CONSTANT 8% INFLATION FACTOR OVER PAST 5 YEARS

Viewgraph 29

Mr. Staker. Just to answer in more detail what Dr. Dillon said, viewgraph 29 discusses the fiscal year 1982 proposed program by the administration as referenced to the fiscal year 1977 program in the prior Carter administration. What we have done is taken the fiscal year 1977 base program funding in the first column, and, using a simple escalator of 8 percent, escalated the various elements to the base program into the fiscal year 1982 equivalent dollars, thus showing the proposed program and finally showing the percent reduction in terms of real investment of R. & D.

Without bemoaning the fact it does show the base program has been scaled back, I think it would be inappropriate in view of our position to develop this technology to take any further cuts in this program.

Mrs. Bouquard. Thank you.

Should the question--and we asked this last week, and I asked you gentlemen for your opinion—of pool versus loop design be looked at seriously in the decision of our LDP? How should the determination of the type of large demonstration plant be made?

Do you see a correlation there, Dr. Dillon?

Dr. Dillon. I think that issue was looked at during the conceptual design study phase, and the decision was to continue with the loop approach. However, I would like to extend a personal view that I think is shared by many people that the difference between the pool and loop concepts is not a dramatic difference. The larger the plants get the closer of a call it becomes. So we don't really feel this has to be a fundamental technological issue.

Mrs. Bouquard. You don't think this will make any difference in decisions in how we construct Clinch River at all?

Dr. Dillon. No. Clinch River will be a loop design. It is 83 percent complete in its design. It is loop.

Mrs. **Bouquard**. Let's touch on our light water reprocessing, if you will, just for a few minutes. Barnwell, West Valley, Morris, Ill., processing plants were constructed as commercial ventures, and barring Government prohibitions in reprocessing of commercial fuel, justified economically. At this time or in the reasonable future can reprocessing again he justified economically? If not, what has changed since the other facilities were constructed?

Dr. **Dillon**. The key to the economics of reprocessing light water fuel has to be the value that is assigned to plutonium. If plutonium were a commodity that could be used, valued in terms of its energy content equivalent to uranium, then reprocessing would be economical. Very close to break-even at this time in terms of the price of uranium which is $30 a pound.

So right now we don't have a practical scheme for using plutonium to generate energy. The breeder reactor will be such a scheme. And there had been discussions of using plutonium in light water reactors.

But absent that capability, there isn't a strong commercial market for plutonium.

Mrs. **Bouquard**. Do you think we should be actively pursuing international cooperative light water reactor reprocessing ventures for the future?

Dr. **Dillon**. Reprocessing technology is a sensitive technology, and I think that we need to continue a trend that has been taking place over the recent years of monitoring international energy developments, including developments in the nuclear area. However, I think that in the case of reprocessing we have to proceed very, very carefully and very cautiously to make sure that we don't inadvertently allow sensitive information to go to a country that we would prefer it not to.

Mrs. **Bouquard**. I was actually referring to this technology that is ours, that we reprocess, that we have our international center where we actually do the reprocessing.

Dr. **Dillon**. If we have a capability for reprocessing, it certainly seems to be in the interest of the country in terms of economics and in terms of our ability to influence other countries in their proliferation objectives. There is much to be gained by having that kind of commercial arrangement with another country. Those are two advantages that would be associated with reprocessing.

Mrs. **Bouquard**. Why are we focusing so much attention on breeder fuel reprocessing, which we really aren't going to be needing right away, when we do need to reprocess light water fuel for, not only waste management, but the fuel cycle, for providing fuels for light water fission? Shouldn't we be focusing more attention in that area?

Dr. **Dillon**. The program we have in the breeder fuel cycle is fairly modest. It is $26 million. It, too, has been honed down from what it had been. We are focusing sharply on the most critical elements of the technology that are unique to breeder reprocessing, and those are developments that will take time.

So it is important to keep a focused technology program going at this time so that when we do have the need to deploy an actual hot facility we will have the technology developed and proven that will make that facility a success.

Mr. **Gates**. There is no question today that the priority is on closing the light water reactor fuel cycle.

Mrs. **Bouquard**. On availability of plutonium for the breeder reactor program, what is the source for the next 20 years?

Dr. **Dillon**. We have not been able to identify a source for the next 20 years. We have, in cooperation with the Office of Nuclear Materials Production, identified a source of plutonium through 1991 that will be adequate for the FFTF and the Clinch River. After 1991 we don't have a secure plan for plutonium for both of them. Even this makes an assumption that the Purex plant will be operational. The Office of Nuclear Materials Production confirms that they should have the capability to provide fuel grade plutonium for FFTF and CRBR through 1991 provided that unforeseen plutonium requirements do not arise, that production facilities continue to operate at capacity, and that plutonium production initiatives proceed as scheduled.

Mrs. **Bouquard**. Thank you very much.

Mr. Lujan?

Mr. **Lujan**. Let me get on to Barnwell a little bit because it concerns me that there has been, I think, an injustice to the owners of Barnwell. Everybody encouraged them to move ahead and then all of a sudden the downfall of the ax. No license. And here it sits.

My understanding was that Secretary Edwards was all in favor of acquiring Barnwell. Has that fallen through?

Mr. **Gates**. I think, Mr. Lujan, that budgetary and financial realities have at least forestalled the earlier emphasis on acquiring Barnwell. I don't know whether that emphasis is dead. I think indeed, sir, that the next move will be for us to examine the degree to which we can entice industry. You made a very astute observation, I believe, that we enticed industry into something and then forestalled their continuing.

Certainly it is our hope and I am sure it is yours, too, that the emphasis that is being placed on revitalizing the nuclear reactor industry by this administration be carried on by whoever the next administration might be so that we stop the business of whipsawing industry.

Mr. **Lujan**. What about—I don't know if we discussed it the last time you reported to the committee—some sort of a Government corporation operating over there on its own funds. When the people from Barnwell were testifying, one of the questions for which they provided some answers, written answers later on—I didn't bring them with me. I am sorry. I thought we were going to be talking about the breeder. But the question was, if we were to form such a Government corporation, strictly as an away-from-reactor storage site for the moment, putting aside the whole question of reprocessing, whether the income realized from such a facility for storing the spent fuel rods would be, first, sufficient to operate the facility, and the answer was "Yes." If the income, then, for the second phase, would there be enough left to rerack to put more spent fuel rods in there, and the answer to that one was "Yes."

If we purchased through some sort of bonds that were issued by the Barnwell authority, whatever you want to call it, apparently if there were enough to pay the interest on those bonds—apparently—the answer was "Yes." And finally to begin retiring the bonds, the principal on the bonds. And apparently the answer was "yes." Has DOE looked into that method of acquiring Barnwell?

Mr. GATES. I am not sure that it has been looked into specifically as of today. It is an option that the Department is aware of, and I am sure that we will be looking into it before long.

That's one system of getting on with it. Another, as I said earlier, is to have industry wholly operate Barnwell. If I followed all your reasoning, Mr. Lujan, relative to whether the reracking and storage and payment for that storage by the reactor owners, the utilities, would pay for certain operations at Barnwell, I am sure you are mindful that currently the administration is looking at away-from-reactor storage from the point of view that industry itself should undertake to make available additional at-reactor storage capability, either by reracking or by additional water wells.

The Department's effort will be to conduct R. & D. on finding other alternative techniques, including the possibilities of dry storage and of disassembling the spent fuel element itself, in order to consolidate and confine the amount of space necessary.

Mr. LUJAN. Are you saying DOE moved away from AFR's?

Mr. GATES. Yes, sir, they have. There are some experiments being carried out or to be undertaken, both at the Nevada Test Site and at the Hanford Reservation that will study dry storage at the surface or slightly below the surface, and then also in deep tunnels. That kind of program is still underway.

Mr. LUJAN. We've had some legislation on dry storage last——

Mr. GATES. Yes.

Mr. LUJAN. Convert some barracks that you had?

Mr. GATES. There was a Senate bill that never became an act of Congress, but from that Senate bill came words in our appropriation relative to the dry storage of spent fuel elements.

Mr. LUJAN. Yes, it was in the waste bill, Dr. Dugan reminds me. In that big waste management bill.

Mr. GATES. The December bill?

Mr. LUJAN. It was finally stripped down, and then we enacted a low-level waste act, as a matter of fact.

Mr. GATES. Yes.

Mr. LUJAN. I gathered at that time that at the Nevada Test Site, you had buildings that could be used for dry storage testing.

Mr. GATES. We do, sir. And that building has been used a great deal in the past 2 years in the encapsulation of 17 spent fuel elements from the Turkey Point reactor in Florida. Eleven of those encapsulated elements are now in what we call the climax granite facility at the northern end of the test site. They are 14 feet underground in a granite tunnel.

Mr. LUJAN. Open air?

Mr. GATES. No. They are in a steel liner, a carbon steel liner that's 14 feet underground.

Mr. LUJAN. No water?

Mr. GATES. No. It's dry storage. Some of the spent fuel elements alternate with heat rods, which give out the same amount of heat as the spent fuel element does. The purpose of the experiment is to find out the reaction not only of the heat itself, but the heat plus the radioactivity on the structure of the rock, the granite. It's what's referred to as a generic study. There is no indication that that particular formation will, in the long run, become a disposal site.

Mr. LUJAN. Are you going to be licensed by NRC, do you think?

Mr. GATES. No, sir.

Mr. LUJAN. Thank you.

Mr. GATES. The reason being that it's R.& D., sir.

Mrs. BOUQUARD. Mr. Wolpe.

Mr. WOLPE. Thank you, Madam Chairman. I would like to pursue a similar line of questioning with respect to Clinch River breeder reactor.

Are there any ground rules for determining the allocation of costs for a project like Clinch River or Barnwell, any of these comparable initiatives, between private industry and the Government? How much at this stage, the development and demonstration phase, does the Government pay for? What are our ground rules? Do we have a rule of thumb that says industry should pick up 5 percent, 10 percent, 50 percent of the cost? What are we operating under here, in terms of a basic understanding?

Dr. DILLON. There is no one specific ground rule for R. & D., because when you think in terms of joint ventures with the Government, we would work in a coordinated way with industry, depending on how far out the profit incentive would be. The Government's share would have to be larger. In the case of Clinch River, the relative shares of funding would be determined by a four-party contract. I would ask Mr. Caffey to say a few words about that.

Mr. CAFFEY. Yes, Mr. Wolpe. With respect to the Clinch River project when it was first constructed as a project, the utility industry took on its responsibility of generating whatever capital contribution that it could among its participating members. It was not a specific proportional share of the estimated cost of the project. It was a best efforts basis to raise whatever money they could. And that amount came to be $257 million.

Mr. WOLPE. That was the industry share?

Mr. CAFFEY. The utility industry's share.

Mr. WOLPE. My understanding was at least as of that point that represented 50 percent of the total then estimated cost of the project——

Mr. CAFFEY. It represented about 35 percent of the total estimated cost at that time.

Mr. WOLPE. That's different from the testimony we received a few days ago, to the effect it was a 50-percent figure. I think perhaps we could have our staff at some point get the reasons for the variation there.

Mrs. BOUQUARD. This will be provided, Mr. Wolpe.

[Information is in committee files.]

Mr. WOLPE. That was on the basis of a total project cost of what?

Mr. CAFFEY. About $699 million estimated in 1972.

Mr. WOLPE. I just read to you Mr. Stockman's 1977 estimated total project cost of $2.7 billion. The other day in a hearing the number of $3 billion was mentioned. Today I heard a figure of $3.5 billion.

Dr. **Dillon**. $3.5 billion was for the large plant. That's another reactor, not for Clinch River.

Mr. **Wolpe**. I see. So what is the latest estimated total cost for the project?

Mr. **Caffey**. Mr. Wolpe, based on a schedule of February 1990 for the plant becoming initially critical, the estimate is just about $3.2 billion.

Mr. **Wolpe**. $3.2 billion. Has there been any thought given, inasmuch as figures have dramatically escalated, thereby reducing by a very large sum the percentage of the private industry contribution, of going back and renegotiating the understanding and commitments on the part of the industry?

Mr. **Caffey**. I think there's been consideration given to that several times. The point has been challenged and raised and discussed a number of times in several years past. The utility industry has felt that it would not be able to raise additional capital contributions.

Mr. **Wolpe**. Why not?

Mr. **Caffey**. Well, because the cost of the project has grown without the ability of the utility industry to manage that cost growth.

Mr. **Wolpe**. If this is so promising in terms of the future growth and development of the utility industry, would you not think that they would be prepared to make a more substantial investment?

Mr. **Gates**. I think there will be an opportunity for industry to participate abundantly in the large demonstration plant. I think the prospect of gross change in industry participation in the CRBR is less likely.

Mr. **Wolpe**. What if the Federal Government simply indicated it wasn't about to continue the project, without insisting upon a fair sharing of cost?

Dr. **Dillon**. Mr. Wolpe, that's part of the problem. That's one of the reasons why the utilities are a little bit reluctant about getting involved in larger investments in this kind of area, because things can happen to a project like Clinch River, over which the utilities would have no control.

Mr. **Wolpe**. For example, it would become less commercial in the light of changes——

Dr. **Dillon**. It could be delayed. The project could be delayed by 4 years. There are a variety of things that can happen to a project, because of Government actions that the utilities have no control over. The rationale on why we're involved at this early stage of the development of the technology, is that the nuclear technologies, more than the other energy technologies, are from the utility viewpoint, vulnerable to Government controls.

Mr. **Wolpe**. But Dr. Dillon, initially the utility was prepared to make a very substantial contribution.

Mrs. **Bouquard**. Would the gentleman yield?

Mr. **Wolpe**. Sure.

Mrs. **Bouquard**. I think testimony will prove this is the largest investment ever made by the private sector to a Federal project. And the stretchout and the costs have been caused by Government actions such as the intense NRC investigation. They have drawn the project out.

Mr. **Wolpe**. I appreciate that observation. I think this happens to be one of the largest Federal projects and, therefore, I think it's reasonable that the industry contribution should be one of the largest contributions as well. But I think—I guess I'm raising as a public policy issue the broader question of whether or not it is reasonable or not for a project that at the time it was initially conceived was thought of as a commercialization venture. And when it was sort of a commercialization venture, the industry was perfectly willing to invest substantial dollars. Now it is not thought of as a commercialization venture. There's a new realization that it's not commercial.

Mr. **Gates**. I'd like to comment just in a general sense, Mr. Wolpe, on the philosophy. To me, for the Federal Government to say to industry, "Put up or we don't go along with it," that would be about the most serious mistake we could possibly make in the 20th century. If this country doesn't move along soon in fast breeder technology, the U.S.S.R, France, Japan, the United Kingdom, and God knows who else, is going to be ahead of us. And I don't think that it's right for the United States to be way behind the countries I've just mentioned.

Mr. **Wolpe**. I might say in response, the same was said about the SST, and thank God we did not decide to compete with the French on that basis.

Mr. **Gates**. I think we should have supported the SST to the hilt.

Mr. **Wolpe**. There seems to be some philosophical difference there. [Laughter.]

Let me just say finally as a last observation, my good friend from New Jersey, a moment ago, was making the point that the rationale for cutbacks in the conservation area, that we should let the market do the job, I would have no quarrel with that whatsoever, if we were equally prepared to allow the market to do the job with respect to electricity and to remove our Price-Anderson subsidy for nuclear power, remove the other kinds of subsidies that exist. And I guess I would be interested in knowing why the market should apply to only one phase of the energy problem, not the other.

Mr. **Gates**. You know, you're getting close to the issue of should military R. & D. and aircraft be disallowed to Boeing. It's part of the same racket. Should space technology be disallowed to the microprocessor, microelectronics industry today? Certainly, the answer has got to be "No." Just as I think it's "No" in what you are espousing, sir.

Dr. **Dillon**. Mr. Wolpe, also one thing I think the people in the nuclear industry, the commercial light water reactor industry, would with some justification take issue with is the idea that they are being heavily subsidized. There are many regulations that these industries are subject to, that take a very heavy toll, like NNPA. So I don't know if that is the best way to think of it. I think there is a market competition going on with regard to light water reactor technology, and there is no Goverment policy to try to influence that for subsidies.

Mr. **Wolpe**. Thank you for your patience, Madam Chairman.

Mrs. **Bouquard**. Thank you very much, Mr. Wolpe, for your highlighting and adding a little controversy to this otherwise unanimously agreed upon hearing today. [Laughter.]

Without you, our meetings might be rather dull. I thank all of you distinguished panelists for being with us this afternoon for this very intense, very valuable testimony.

I think at this time the subcommittee will stand in recess until about 3:30, when we will have Admiral Rickover with us to present his testimony for our budget hearings. We are running ahead of schedule. We will take the next 25 minutes for a recess.

We are delighted to have with us this afternoon Admiral H. G. Rickover who is Deputy Assistant Secretary for Naval Reactors.

We welcome you, Admiral Rickover. Please proceed with your testimony.

## STATEMENT OF HYMAN G. RICKOVER, DEPUTY ASSISTANT SECRETARY FOR NAVAL REACTORS, OFFICE OF NUCLEAR ENERGY, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY JAMES PALMER, PROGRAM MANAGER FOR SURFACE SHIPS AND WATER COOLED BREEDER; AND T. L. FOSTER, DIRECTOR, OFFICE OF FISCAL ACQUISITION AND LOGISTICS MANAGEMENT

Admiral Rickover. Good afternoon, Madam Chairman and members. I am very pleased and privileged to be here once more.

In addition to my responsibilities for the naval nuclear propulsion program, I have been in charge of a portion of the civilian reactor development program since 1953.

Based on my reactor development experience, I was assigned responsibility within the Atomic Energy Commission for developing and building the pressurized water reactor for the Shippingport Atomic Power Station which started producing electricity in 1957. This was the first civilian central station nuclear powerplant in the United States.

Shippingport now contains the Nation's first light water breeder reactor core, which was developed under my direction. From that perspective, I would like to comment on the Department of Energy's water cooled breeder program.

There is no magic solution to the energy problem—one which will provide abundant energy without causing environmental problems, taxing our limited resources, and causing other undesirable side effects. The energy problem won't be solved by wishful thinking—we have to approach it from a hardheaded, pragmatic standpoint.

All potential forms of energy—fossil—wood, oil, gas, coal—hydroelectric, nuclear fission and fusion, geothermal, solar, and other more exotic concepts—have drawbacks. There is no free lunch. Having an adequate supply of energy is so essential to our Nation that we need to pursue energy research on a variety of fronts. Technology doesn't respect polls, commercial interests, or economic analyses. We need to find out what can be done with the various technologies before putting all our eggs in one basket.

There is a world of difference between ideas, theoretical concepts, and practical applications. During the early part of this century, I read that the potential energy in a teaspoonful of water, if it could be harnessed, would propel an auto across the continent. Yet generating useful power from nuclear fission was not a reality until nearly a half century later. Jules Verne's vision of a true submersible did not become reality until more than 80 years later when the U.S.S. *Nautilus* put to sea.

In developing the *Nautilus*, I found the work was 5 percent scientific and 95 percent engineering. That is a very important point I want to make, because most people think that nuclear energy is a result of pure scientific thought. It is not. Scientists have at least as many ideas as it would take—for each idea it would take 1,000 engineers to develop and put into effect. This is a fundamental and little understood fact that applies to the entire energy research and development effort in this country. The theorists have many concepts that would solve the energy problem. Developing their concepts and reducing them to practical application is a long, arduous, expensive, and sometimes fruitless task.

There is a wealth of experience in water as a medium for the exchange of heat dating back to Watt's steam engine and even to the steam machines developed by Hero of Alexandria. Yet it was an education to many during the early days of the nuclear program to find how little engineering had been done in the design of valves, pumps, and other relatively simple engineering devices and how difficult it is to make them reliable in nuclear applications.

Nuclear power requires devices that will operate for many years in a hostile environment of radiation, high temperature, and pressure, inside a reactor. Even today after more than a quarter century of experience in operating reactors we are still learning about the long-term effects of these conditions on reactor materials, and about such seemingly mundane matters as valve design. For example, I am doing some work now on trying to develop a naval nuclear core that will last for the life of a ship, 30 years. You can imagine what that does to material. To take material, have it bombarded constantly with radiation, and have it maintain tolerances of a few thousandths of an inch after 30 years, that is quite a job to work on. Very few people realize the vast difficulties that are involved in doing that type of engineering.

So you must realize that developing nuclear cores that last longer, thus giving you less radiation exposure, involves a tremendous engineering feat. It is not anywhere near as much of a scientific feat. I would say the scientific part is about 1 percent of the whole problem. It is really an engineering problem. Originally when I started in 1946 it was conceived to be a physics problem. It is not. The physics is easy.

Out of about 300 technical people I have working in my organization 2 are physicists, and this is quite the opposite from what it was in the beginning of the program. It was the other way around. So when I got into developing practical reactors that would last a long time and be safe it is an engineering problem.

Breeder nuclear reactors offer vast energy potential for this country. Today nuclear power is limited by the availability of uranium-235 which makes up only seven-tenths of 1 percent of natural uranium. Without breeder reactors, nuclear power offers less energy potential than known fossil fuel resources. We will likely have to rely on breeders to meet future energy needs even if current standards of living are reduced as our fossil fuel reserves diminish.

The liquid metal fast breeder reactor is the priority program within the breeder development effort. I endorse the liquid metal breeder program because of the theoretical potential it offers. I understand that the current plans for its development effort are to bring on line by 1990 a demonstration plant to try out the various components for liquid metal breeders in an operating powerplant.

Liquid metal is more efficient than light water as a heat transfer medium. Liquid metal breeders offer the possibility for generating enough fuel to refuel the reactor itself and produce an excess which can be used toward fueling another reactor. Yet there are numerous technical difficulties that must be overcome before consideration can be given to application of liquid metal breeders. These center around the use of high temperature liquid metal as a coolant.

In the early days of the naval nuclear propulsion program scientists and engineers pointed out that light water as a coolant does not offer many of the theoretical advantages of high-temperature gas, molten salt, liquid metal and organic coolants.

I explored various alternatives. It turned out that the practicality of ordinary water as a coolant was overriding. I tried liquid metal, I tried organics also. I actually designed, built and operated a prototype liquid metal reactor and installed and operated one in a submarine. The liquid metal reactor operated in that submarine for about 2 years.

Based on this experience, however, I concluded liquid metal was not suitable for naval applications. Specifically, liquid sodium ignites and burns violently when exposed to air and water—a characteristic of particular concern onboard ship. Moreover, the much higher radiation levels in this plant after reactor shutdown made it far more difficult and time consuming to maintain and repair. For example, with a water cooled reactor we can enter the reactor compartment in 15 minutes. With a liquid metal reactor it would be 10 days. If anything was wrong we had to wait 10 days before we could get into it. Of course, in a shore plant you don't have that urgency.

Because of the urgent need for a nuclear-powered submarine, I tried out alternatives, not knowing which would be best for naval ships. I then made the final selection based on actual operating experience. In view of the importance of energy to our Nation's future, I believe this would also be a wise approach to follow in the breeder program.

Based on my experience in developing light water reactor technology for the naval nuclear propulsion program, I was assigned responsibility by the Atomic Energy Commission in 1953 to design and build the first central station nuclear powerplant, the Shippingport Atomic Power Station. Mind you, at that time, it only took 4 years from getting permission to build a plant to have it operating. God knows how long it takes now.

My work in civilian nuclear power development led in the 1960's to my assignment by the Atomic Energy Commission to initiate development of the light water breeder reactor (LWBR) to improve the efficiency of using nuclear fuel to generate electric power. An LWBR core is installed and currently operating in the Shippingport plant. The LWBR concept is a self-sustaining breeder reactor cooled and moderated with ordinary light water and fueled with uranium-233 and thorium.

The breeding potential of light water breeder reactors is less than that of fast breeders such as the liquid metal breeder. An LWBR would be capable of providing at each refueling enough fissile fuel to manufacture a replacement core without having to mine more uranium; however, it would not provide excess fuel for other reactors. Nonetheless, LWBR's have the advantage of operating in an easier medium—water—and making use of thorium, an untapped energy resource.

There's probably more energy to be obtained from thorium than there is from uranium. So if you look to the future, here is another vast energy source that is being demonstrated in this reactor.

Thorium offers a source of potential energy many times greater than the world's total oil and coal reserves. The LWBR concept is the only known approach using light water thermal reactor technology to substantially improve fuel utilization efficiency beyond that achievable with present types of light water reactors.

Light water reactor technology is well understood and has been demonstrated to be practical by over 25 years of experience. Almost all of the power reactors currently in operation or being planned in this country are of the light-water type. This permits concentrating the development effort on the breeder core technology without the technical risks, uncertainties, and cost of developing a new kind of powerplant.

I am continuously beset with demands to know of commercial interest in the LWBR and to produce economic analyses proving LWBR is competitive. There are many technical problems and policy issues to settle concerning any breeder reactors before widespread commercial application of breeder technology is possible. These include developing remote fuel fabrication, evaluating the feasibility of other breeder concepts, and resolving the issues and technical problems involved with nuclear fuel reprocessing and waste disposal. Neither I nor anyone else can predict what the outcome will be.

Until there is an adequate technology base to demonstrate their practicability, it is a waste of time to try to compare the relative costs of commercializing various alternatives. I doubt that you can find any nuclear power cost comparison studies done 10 or 20 years ago that are worth the paper they are written on. If anything, the energy future is more unpredictable today than it was 20 years ago.

It is worth remembering that, at the time I started and was building the Shippingport reactor in the mid-1950's, there was little if any commercial interest in light water reactors. They were thought to be uneconomical in relation to other alternatives. Today, however, practically the entire nuclear industry in this country and abroad is based on the light water technology.

We couldn't get a single utility at that time to contribute a dollar for light water reactor research and development, which they all use now. The issue comes up: Why don't you get support from the industry? Industry is only interested in making profits; it's not interested in anything else.

Shortly after the Three Mile accident, I arranged for the 10 or 11 top utility executives in the United States to come to my office and spend a while to tell them how we ran the plant, why they were safe, why we have never had any accidents. I then took them around to our prototypes in Idaho, and showed them.

That was the end of it. These people are not interested in technology; they are interested in the bottom line, and you have to recognize that. So if any of this work is going to be done, it's going to be done by the Government—or it won't be done. That's a matter of fact. I don't know how to do away with it. If they were to give us money, we'd be happy to take it. This would go for anyone, including any visitors here or even members sitting up on the platform. If you have any extra money, Madam Chairman——

Mrs. BOUQUARD. Would you like me to pass the hat?

Admiral RICKOVER. Yes. That's right. [Laughter.]

An LWBR core rated at 60 megawatts electrical net is currently installed and operating at Shippingport Atomic Power Station. The core is highly instrumented to provide valuable technical data during operation. For more than 3 years the LWBR core has been operating successfully, supplying power to the Duquesne Light Co. power distribution system.

The original lifetime objective of the Shippingport core was 15,000 effective full power hours while breeding. Already we have accumulated more than 20,000 hours, and generated more than 1.2 billion net kilowatt-hours of electrical energy. Based on present nuclear and reactor engineering calculations and test data from operation of the core, I have approved operation through 24,000 hours and I am assessing the core's capability to operate to 30,000 hours. Mind you, I only promised 15,000. We expect to get 30,000 hours out of it.

The reason I am mentioning this is I make it a point at all times in testifying to Congress never to say that I will do more than I can. And I have always more than met what I have said. I would rather do it that way than the other way.

Data from Shippingport indicates that the core is breeding. However, to confirm that it performed and bred as predicted, the core will be shipped to the naval reactors' expended core facility in Idaho upon removal from Shippingport to verify performance, including direct measurement of breeding characteristics.

Shippingport is the only power reactor ever to be operated exclusively with uranium-233 and thorium fuel. Operation at Shippingport indicates the LWBR core is capable of very long life.

In future designs, this long life potential could be valuable in achieving maximum fuel utilization, reduced costs, and minimum reprocessing and refabrication of reactor fuel with attendant reduction in radiation exposure and radioactive waste.

And that is a very important point, which is lost sight of frequently. By making these cores last a long time, you drastically reduce the amount of residue or radioactive waste that you have to process and which becomes a permanent detriment to the United States.

That's one of the bad things about nuclear power: you produce radioactive waste material. This system would produce a minimum of radioactive material.

Continued operation of the core in the Shippingport plant offers an economical opportunity to demonstrate more fully the technology of the uranium-233 and thorium fuel system, providing important technical information not only for evaluating the future potential of LWBR's, but also for more efficient use of nuclear fuel resources in light water reactors. It is our only opportunity to demonstrate the practicality of such long lived cores and to gain important information on how the reactor performs late in core life.

Development and construction of the light water breeder core has resulted in a wealth of technical information; however, it was designed and built based on technology developed in the 1960's and early 1970's. Since that time, valuable experience has been gained from the Shippingport operation and from other advances in light water reactor technology.

To build on this experience and to develop information that would be useful in applying this technology on a commercial scale, I established a separate program called advanced water breeder applications.

The main thrust of this effort is to improve breeding performance beyond the Shippingport core capability, to develop prebreeder concepts that would be needed to start up light water breeders, and to disseminate technical information on it to industry.

Taken together, the three constituent parts of my water-cooled breeder program—Shippingport, LWBR, and advanced water breeder applications—will provide technology needed by those who must eventually decide among energy alternatives. This information will already be available by the time the liquid metal breeder is operating in the Clinch River reactor.

Should the liquid metal breeder concept not prove to be practical for widespread application, the ready availability of light water breeder reactor technology as an alternative would be worth far more than the relatively small amount of money we will be spending to develop it.

I do not advocate light water breeder reactors as the only solution to our energy problem. I am saying that, given the vast sums that must be spent on energy development, the amount I am requesting to continue work on the water-cooled breeder program is a good investment. I recommend that Congress continue to support the water-cooled breeder program at the recommended levels.

Admiral RICKOVER. That concludes my statement. I will be glad to answer any questions.

[The prepared statement of Admiral Rickover follows:]

# Statement on
# Water Cooled Breeder Program
by Admiral H. G. Rickover
Deputy Assistant Secretary for Naval Reactors
before the
Energy Research and Production Subcommittee
of the
House Committee on Science and Technology

In addition to my responsibilities for the Naval Nuclear Propulsion Program, I have been in charge of a portion of the civilian reactor development program since 1953. Based on my reactor development experience, I was assigned responsibility within the Atomic Energy Commission for developing and building the pressurized water reactor for the Shippingport Atomic Power Station which started producing electricity in 1957. This was the first civilian central station nuclear power plant in the United States. Shippingport now contains the nation's first Light Water Breeder Reactor core, which was developed under my direction. From that perspective, I would like to comment on the Department of Energy's Water Cooled Breeder program.

There is no magic solution to the energy problem -- one which will provide abundant energy without causing environmental problems, taxing our limited resources, and causing other undesirable side effects. The energy problem won't be solved by wishful thinking -- we have to approach it from a hard-headed, pragmatic standpoint.

All potential forms of energy -- fossil (wood, oil, gas, coal), hydroelectric, nuclear fission and fusion, geothermal, solar, and other more exotic concepts -- have drawbacks. There is no free lunch. Having an adequate supply of energy is so essential to our nation that we need to pursue energy research on a variety of fronts. Technology doesn't respect polls, commercial interests, or economic analyses. We need to find out what can be done with the various technologies before putting all our eggs in one basket.

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There is a wealth of experience in water as a medium for the exchange of heat dating back to Watt's steam engine and even to the steam machines developed by Hero of Alexandria. Yet, it was an education to many during the early days of the nuclear program to find how little engineering had been done in the design of valves, pumps, and other relatively simple engineering devices and how difficult it is to make them reliable in nuclear applications. Nuclear power requires devices that will operate for many years in a hostile environment of radiation, high temperature, and pressure, inside a reactor. Even today after more than a quarter century of experience in operating reactors we are still learning about the long term effects of these conditions on reactor materials, and about such seemingly mundane matters as valve design.

Breeder nuclear reactors offer vast energy potential for this country. Today, nuclear power is limited by the availability of uranium-235 which makes up only 7 tenths of 1 percent of natural uranium. Without breeder reactors, nuclear power offers less energy potential than known fossil fuel resources. We will likely have to rely on breeders to meet future energy needs even if current standards of living are reduced as our fossil fuel reserves diminish.

The Liquid Metal Fast Breeder Reactor is the priority program within the breeder development effort. I endorse the liquid metal breeder program because of the theoretical potential it offers. I understand that the current plans for its development effort are to bring on line by 1990 a demonstration plant to try out the various components for liquid metal breeders in an operating power plant. Liquid metal is more efficient than light water as a heat transfer medium. Liquid metal breeders offer the possibility for generating enough fuel to refuel the reactor itself and produce an excess which can be used toward fueling another reactor. Yet there are numerous technical difficulties that must be overcome before consideration can be given to application of liquid metal breeders. These center around the use of high temperature liquid metal as a coolant.

In the early days of the Naval Nuclear Propulsion Program, scientists and engineers pointed out that light water as a coolant does not offer many of the theoretical advantages of high temperature gas, molten salt, liquid metal and organic coolants. I explored various alternatives. It turned out that the practicality of ordinary water as a coolant was overriding. I actually designed, built, and operated a prototype liquid metal reactor and installed and operated one in a submarine. The liquid metal reactor operated in that submarine for about two years. Based on this experience, however, I concluded liquid metal was not suitable for naval applications. Specifically, liquid sodium ignites and burns violently when exposed to air and water - a characteristic of particular concern onboard ship. Moreover, the much higher radiation levels in this plant after reactor shutdown made it far more difficult and time consuming to maintain and repair.

Because of the urgent need for a nuclear powered submarine, I tried out alternatives, not knowing which would be best for naval ships. I then made the final selection based on actual operating experience. In view of the importance of energy to our nation's future, I believe this would also be a wise approach to follow in the breeder program.

Based on my experience in developing light water reactor technology for the Naval Nuclear Propulsion Program, I was assigned responsibility by the Atomic Energy Commission in 1953 to design and build the first central station nuclear power plant, the Shippingport Atomic Power Station. The plant was completed and began producing electricity in 1957. My work in civilian nuclear power development led in the 1960's to my assignment by the Atomic Energy Commission to initiate development of the Light Water Breeder Reactor (LWBR) to improve the efficiency of using nuclear fuel to generate electric power. An LWBR core is installed and currently operating in the Shippingport plant. The LWBR concept is a self-sustaining breeder reactor cooled and moderated with ordinary light water and fueled with uranium-233 and thorium.

The breeding potential of light water breeder reactors is less than that of fast breeders such as the liquid metal breeder. An LWBR would be capable of providing at each refueling enough fissile fuel to manufacture a replacement core without having to mine more uranium. However, it would not provide excess fuel for other reactors. Nonetheless, LWBRs have the advantage of operating in an easier medium, water, and making use of thorium - an untapped energy resource. Thorium offers a source of potential energy many times greater than the world's total oil and coal reserves. The LWBR concept is the only known approach using light water thermal reactor technology to substantially improve fuel utilization efficiency beyond that achievable with present types of light water reactors.

Light water reactor technology is well understood and has been demonstrated to be practical by over 25 years of experience. Almost all of the power reactors currently in operation or being planned in this country are of the light water type. This permits concentrating the development effort on the breeder core technology without the technical risks, uncertainties, and cost of developing a new kind of power plant.

I am continuously beset with demands to know of commercial interest in the LWBR and to produce economic analyses proving LWBR is competitive. There are many technical problems and policy issues to settle concerning any breeder reactors before widespread commercial application of breeder technology is possible. These include developing remote fuel fabrication, evaluating the feasibility of other breeder concepts, and resolving the issues and technical problems involved with nuclear fuel reprocessing and waste disposal. Neither I nor anyone else can predict what the outcome will be.

Until there is an adequate technology base to demonstrate their practicability, it is a waste of time to try to compare the relative costs of commercializing various alternatives. I doubt that you can find any nuclear power cost comparison studies done 10 or 20 years ago that are worth the paper they are written on. If anything, the energy future is more unpredictable today than it was 20 years ago.

It is worth remembering that, at the time I started and was building the Shippingport reactor in the mid 1950's, there was little, if any commercial interest in light water reactors. They were thought to be uneconomical in relation to other alternatives. Today, however, practically the entire nuclear industry in this country and abroad is based on the light water technology.

An LWBR core rated at 60 megawatts electrical (MWe) net is currently installed and operating in the Shippingport Atomic Power Station. The core is highly instrumented to provide valuable technical data during operation. For more than three years the LWBR core has been operating successfully, supplying power to the Duquesne Light Company power distribution system. The original lifetime objective of the Shippingport core was 15,000 effective full power hours (efph) while breeding. Already we have accumulated more than 20,000 efph of operation and generated more than 1.2 billion net kilowatt-hours of electrical energy. Based on present nuclear and reactor engineering calculations and test data from operation of the core, I have approved operation through 24,000 efph and I am assessing the core's capability to operate to 30,000 efph and beyond.

Data from Shippingport indicates that the core is breeding. However, to confirm that it performed and bred as predicted, the core will be shipped to the Naval Reactors' Expended Core Facility in Idaho upon removal from Shippingport to verify performance, including direct measurement of breeding characteristics.

Shippingport is the only power reactor ever to be operated exclusively with uranium-233 and thorium fuel. Operation at Shippingport indicates the LWBR core is capable of very long life. In future designs, this long life potential could be valuable in achieving maximum fuel utilization, reduced costs, and minimum reprocessing and refabrication of reactor fuel with attendant reduction in radiation exposure and radioactive waste. Continued operation of the core in the Shippingport plant offers an economical opportunity to demonstrate more fully the technology of the uranium-233 and thorium fuel system, providing important technical information not only for evaluating the future potential of LWBR's, but also for more efficient use of nuclear fuel resources in light water reactors. It is our only opportunity to demonstrate the practicality of such long lived cores and to gain important information on how the reactor performs late in core life.

Development and construction of the Light Water Breeder core has resulted in a wealth of technical information. However, it was designed and built based on technology developed in the 1960's and early 1970's. Since that time, valuable experience has been gained from the Shippingport operation and from other advances in light water reactor technology. To build on this experience and to develop information that would be useful in applying this technology on a commercial scale, I established a separate program called Advanced Water Breeder Applications. The main thrust of this effort is to improve breeding performance beyond the Shippingport core capability, to develop prebreeder concepts that would be needed to start up light water breeders, and to disseminate technical information on it to industry.

Taken together, the three constituent parts of my Water Cooled Breeder program -- Shippingport, LWBR, and Advanced Water Breeder Applications -- will provide technology needed by those who must eventually decide among energy alternatives. This information will already be available by the time the liquid metal breeder is operating in the Clinch River reactor.

Should the liquid metal breeder concept not prove to be practical for widespread application, the ready availability of light water breeder reactor technology as an alternative would be worth far more than the relatively small amount of money we will be spending to develop it.

I do not advocate light water breeder reactors as the only solution to our energy problem. I am saying that, given the vast sums that must be spent on energy development, the amount I am requesting to continue work on the Water Cooled Breeder Program is a good investment. I recommend that Congress continue to support the Water Cooled Breeder Program at the recommended levels.

Details concerning the Water Cooled Breeder Program FY 1982 budget request are contained in the Appendix.

Appendix

## WATER COOLED BREEDER PROGRAM BUDGET

The Water Cooled Breeder Budget Request for FY 1982 is:

| | Budget Authority ($ in millions) |
|---|---|
| Operating Funds: | |
| Shippingport Atomic Power Station | $12.0 |
| Light Water Breeder Reactor | $26.0 |
| Advanced Water Breeder Applications | $19.0 |
| Plant and Capital Equipment Funds: | $ 1.0 |
| TOTAL WATER COOLED BREEDER | $58.0 |

The $58 million requested, which includes $1 million in capital equipment funds, provides for continuation of the current program and will maintain a level of technical expertise necessary to meet the objectives of the program. The total funds requested for FY 1982 are $2.2 million less than requested in FY 1981 in spite of the effects of inflation.

### SHIPPINGPORT ATOMIC POWER STATION $12.0 million

The Shippingport Atomic Power Station program's objective continues to be advancing pressurized water reactor technology through testing of advanced reactor concepts. The experience gained from operating the Shippingport Atomic Power Station provided the basis for much of the technology leading to present central station light water nuclear power plants.

The operation of the Light Water Breeder Reactor (LWBR) in the Shippingport plant is an extension of the development work that has been carried out at this facility since its initial operation in 1957.

Since start-up, the LWBR core has operated successfully in both sustained operation at high power and periodic swing-load operations during which reactor power has been varied to meet power load demands. The LWBR has operated more than three years and accummulated over 20,000 effective full power hours.

## Operation of Shippingport Atomic Power Station

The Shippingport Atomic Power Station is operated for the Department of Energy (DOE) by the Duquesne Light Company, a public utility. The plant supplies power to Duquesne's power distribution grid for the Pittsburgh, Pennsylvania area. The reactor portion of the plant is owned by the Government while Duquesne owns the turbine portion. Duquesne operates the plant on a no fee basis and pays the Government for the steam produced by the plant. The revenue is not used to offset the Shippingport Atomic Power Station budget request, rather the revenues go into a general DOE account.

| Manyears | Labor/Overhead | Materials | Total |
|---|---|---|---|
| 216 | $8,990,000 | $2,645,000 | $11,635,000 |

In FY 1982, operation of the Shippingport Atomic Power Station will continue. This involves various efforts which include: reviewing plant operation and performance; performing periodic tests of the LWBR reactor core to confirm the predictions of characteristics; maintaining the Shippingport Atomic Power Station; and performing necessary chemical analysis to ensure efficient operation of the plant.

## PWR-2 Core Efforts

Prior to installation of the LWBR core in the Shippingport station reactor, the PWR-2 core was installed. This core was removed in 1975. The expended core is being examined at the Expended Core Facility.

| Manyears | Labor/Overhead | Materials | Total |
|---|---|---|---|
| 8 | $285,000 | $80,000 | $365,000 |

During FY 1982, data obtained from nondestructive fuel examinations of the PWR-2 core fuel system at the Expended Core Facility will be used to evaluate irradiation effects on light water reactors. Assessment and disposal of PWR-2 components will continue, including: evaluating expended components to obtain cladding and fuel performance destructive examination data; shipping and disposing of residual PWR-2 components; completing fabrication of the lower core barrel shipping container; preparing procedures for shipping the PWR-2 lower core barrel; and providing continuing technical coverage of shield design and radiation analyses to support PWR component disposal and storage.

## LIGHT WATER BREEDER REACTOR $26.0 million

The Light Water Breeder Reactor program's objective is to accomplish three things: prove that breeding can be achieved in a light water nuclear power plant using a thorium/uranium-233 fuel system; confirm a practical way to use thorium, a plentiful source of fuel for which there has been no major energy-related use; and show that it is feasible to install prebreeder and breeder cores of the LWBR type in existing and future pressurized water reactor plants using existing types of components and systems. Another technical benefit of this program is the significant improvements in the efficiency of using nuclear fuel resources that are expected to be realized from LWBR technology.

The two areas of effort are: technical support for operating the LWBR core and preparations for the LWBR end-of-life effort.

## Technical Support for LWBR Core Operations

The Duquesne Light Company operates the LWBR reactor and conducts necessary tests on the reactor. However, analyses and evaluation of test results, development of test programs and applicable procedures, and technical questions concerning the reactor and core predictions are handled by the Bettis Atomic Power Laboratory.

| Manyears | Labor/Overhead | Materials | Total |
|---|---|---|---|
| 82 | $6,200,000 | $1,400,000 | $7,600,000 |

During FY 1982, the program will continue to provide technical support for operation of the LWBR core. This work includes: monitoring LWBR nuclear performance through periodic core follow calculations; evaluating test results to confirm predicted core performance and to provide data for the end-of-life test program; evaluating movable fuel assembly scram data and core flow distribution data; and providing instrumentation, control, and electrical power system design and operational support for LWBR.

Efforts to establish how long the reactor is capable of operating to maximize breeding and demonstrate the U-233/$ThO_2$ fuel system will include: performing thermal and hydraulic analyses; conducting fuel element, grid, and structural analyses; providing mechanical and fluid systems engineering support; and performing evaluations of postulated plant accidents. Tests and evaluations of fuel, cladding, and structural samples will also be conducted to determine the effects of irradiation on water cooled reactor components.

The data obtained from the LWBR program is analyzed and provides the basis for conceptual designs of improved breeder and prebreeder reactors in the Advanced Water Breeder Applications program.

## LWBR End-of-Life Effort

The LWBR end-of-life effort encompasses the activities required upon completion of core operation and the preparations leading up to these activities. The activities consist of core tests following shutdown, fuel removal and partial disassembly at Shippingport, shipping, and fuel module receipt, unloading, disassembly, and examinations at the Expended Core Facility. The ECF examinations will include determination of core breeding performance and examination of expended fuel rods and support structure to determine their performance throughout core life. Preparations are presently underway for the end-of-life effort including design, procurement and testing of major equipment and preparation of procedures.

| Manyears | Labor/Overhead | Materials | Total |
|---|---|---|---|
| 180 | $13,600,000 | $4,800,000 | $18,400,000 |

Preparations for the LWBR end-of-life effort will continue in FY 1982 including: completing preparation of guidelines, training procedures, and operational procedures for LWBR defueling; conducting LWBR fuel handling and shipping checkout program at Shippingport. Procurement will be completed of major equipment needed to disassemble and examine LWBR modules at ECF and equipment installation and checkout will continue. Also, checkout and qualification of LWBR cutting equipment will also be completed. Further proof testing of the Production Irradiation Fuel Assay Gage (PIFAG) at Bettis will be conducted. Required modifications to hot cells designated for PIFAG installation at ECF will be completed. The PIFAG will be used to measure the fissile fuel content of the expended LWBR fuel rods. The information obtained will be used to confirm breeding performance; that is, to show that the fissile fuel content of the expended LWBR core is greater than it was at beginning of life.

ADVANCED WATER BREEDER APPLICATIONS $19.0 million

The Advanced Water Breeder Applications (AWBA) program's focus is on exploring technical problems and developing and disseminating technical information through published technical reports. This work is proceeding in parallel with operation of the Shippingport LWBR core and is planned to continue through examination of the spent core after it reaches end-of-life.

Major emphasis within the AWBA program is on improving breeding performance in light water breeder reactors. The Shippingport LWBR core was designed and built based on technology developed in the 1960's and early 1970's. Since then, valuable experience has been gained from the operation of LWBR and from other advances in light water reactor technology. The Advanced Water Breeder Application effort builds on this LWBR experience and develops information that would be useful in applying this technology on a commercial scale.

Improved methods for producing uranium-233 in water cooled breeders and prebreeders are being designed and developed. To operate an LWBR, an initial fuel loading of uranium-233 is necessary. Because uranium-233 is not available in nature, this initial loading must be produced from thorium by some means such as the operation of a nuclear power plant. Once enough uranium-233 is accumulated to put a light water reactor on the breeding cycle the increment of capacity represented by that reactor would become self-sustaining without further mining and enrichment of uranium. The only makeup fuel required would be small amounts of thorium.

Work is underway to develop and disseminate technical information based on experience and technology related to LWBR. To date, over 300 technical reports of Water Cooled Breeder technology have been published and are available from Government publication sources.

Technical areas requiring further development for the uranium-233/thorium fuel system include reactor design concepts, fuel fabrication process technology, fuel element design, and reactor mechanical design.

## Reactor Design Concepts

The purpose is to develop conceptual designs for commercial-scale prebreeder and breeder reactors utilizing both the basic technology developed from the Shippingport LWBR and advanced methods for improving reactor performance. These conceptual designs include: a commercial-scale reactor based on a direct scale up of the 60 MW(e) Shippingport LWBR, commercial-scale breeder reactors with improved breeding performance, and prebreeders which more efficiently produce U-233 than concepts which have been evaluated to date. Testing is performed to confirm these designs.

| Manyears | Labor/Overhead | Materials | Total |
|---|---|---|---|
| 26 | $1,600,000 | $637,000 | $2,237,000 |

During FY 1982 reactor design concept development efforts will include completing the analysis of a commercial scale water cooled breeder based on Shippingport LWBR core technology. Conceptual design of prebreeder reactors will continue. Evaluation of alternative advanced breeder concepts will continue to determine the best concept for further detailed design. A movable-fuel controlled breeder based on the Shippingport LWBR and two breeder concepts using thoria finger control rods of different configurations are being evaluated.

## Fuel Fabrication Process Technology

The purpose is to simplify the process which was used for the manufacture of fuel for the Shippingport LWBR to make it more amenable for use on a large scale basis as well as to develop special advanced fabrication processes. In addition, this work includes the development and fabrication of irradiation test rods for advanced prebreeder and breeder rod and bundle tests.

| Manyears | Labor/Overhead | Materials | Total |
|---|---|---|---|
| 47 | $2,900,000 | $1,595,000 | $4,495,000 |

In FY 1982, efforts in this category will continue, including: evaluating the use of radially-zoned fuel pellets to simplify the current fuel system fabrication process; completing evaluation of the fabrication feasibility of finned and dimpled zircaloy tubes; evaluating technology for use in an advanced thoria finger rod control concept; documenting various refinements made in fuel fabrication process technology to simplify fabrication and reduce process losses for thoria based fuel pellets; and developing and fabricating the fuel elements for advanced fuel rod tests and for the breeder bundle irradiation test.

## Fuel Element Design

The purpose is to define and evaluate performance features for improved prebreeder and breeder fuel elements which use the urania-thoria dioxide fuel system, to conduct performance evaluations of these fuel elements both for irradiation tests and verification of conceptual designs and to develop improved methods for fuel element design and performance analyses.

| Manyears | Labor/Overhead | Materials | Total |
|---|---|---|---|
| 45 | $2,723,000 | $7,080,000 | $9,803,000 |

Fuel element design work in FY 1982 includes: conducting irradiation tests to provide data on the effects of higher power on fuel element performance and to improve the stress corrosion cracking power transient capability of the uranium-233/thorium fuel; performing irradiation tests of advanced fuel concepts to establish comparative performance and to determine iodine and fission product release; completing design of fuel for a breeder bundle irradiation test; and developing improved fuel rod analysis methods and techniques to upgrade calculational models for advanced fuel systems in an effort to reduce uncertainties in fuel rod performance predictions.

## Reactor Mechanical Design

The purpose is to develop and demonstrate the feasibility of advanced features necessary to improve breeding performance in advanced breeder reactors. These advanced features include: the use of zircaloy fuel support grids on a close-packed triangular pitch and the movable thoria finger control system. This effort includes the necessary fabrication development and testing.

| Manyears | Labor/Overhead | Materials | Total |
|---|---|---|---|
| 32 | $1,960,000 | $505,000 | $2,465,000 |

Reactor mechanical design efforts in FY 1982 will include: developing and testing machined and stamped piece zircaloy grids to determine their acceptability to support fuel rods in a close packed triangular array; continuing the development and tests of a thoria finger rod control system which has the theoretical potential to improve breeding and reduce peak-to-average power density. Also, preliminary critical heat flux tests in support of thoria finger control rods will be performed; this is important because a unique feature of the thoria finger control rod is its heat generation, which must be tested to confirm the analytical ability to predict performance.

## CAPITAL EQUIPMENT $1.0 million

Capital equipment funds are needed in FY 1982 to support continued operation of the Shippingport Atomic Power Station and research and development efforts in the Light Water Breeder Reactor and Advanced Water Breeder Applications programs. These programs require equipment to support LWBR end-of-life efforts, the development of improved breeding technology aimed at increasing fuel utilization and the development of prebreeder concepts. This equipment includes defueling, shipping, core examination, proof-of-breeding, process development, irradiation test support, and fuel development test equipment.

Mrs. BOUQUARD. Thank you very much, Admiral Rickover, for your expertise, for your dedication to the programs of our Nation.

The Shippingport reactor has been scheduled to shut down at the completion of its light water breeder demonstration in 1982. I understand that you are now planning to operate the Shippingport core until early 1985. I also understand that you have indicated to the GAO that the extended high burnup of uranium 233/thorium oxide fuel system can be accomplished at the advanced test reactor in Idaho at a cost of $20 million. In addition, I understand that the higher burnup of the Shippingport core will actually reduce the breeding gain, the key focus of your program, Admiral.

Given these two factors, how can we justify the 3 years of operation at the Shippingport reactor for approximately $200 million, which is 10 times the cost of this accomplishment in the Idaho facility.

Admiral RICKOVER. In the first place, we are actually operating something, a power reactor. In the second place, in my opinion, energy is so valuable that you must not waste any. I don't think—the last thing you can afford to waste is energy. If you've got a source of energy, even if it costs more money, the energy is more important than the money.

Mrs. BOUQUARD. But it can't be accomplished at the Idaho facility.

Admiral RICKOVER. No; it can't be accomplished quite as well because here you have a real reactor operating under reactor conditions. The rest of it is all test reactors. You don't operate them like a real power reactor.

[The information follows:]

### SUPPLEMENTAL INFORMATION ON THE NEED FOR CONTINUING SHIPPINGPORT LIGHT WATER BREEDER OPERATION

Neither Admiral Rickover nor his staff told the General Accounting Office that an irradiation experiment in a test reactor could substitute for continued operation of the Shippingport light water breeder in providing technical information about the high burn-up performance capability of the uranium-233 and thorium fuel system. Naval Reactors has used irradiation tests in both its naval and Water Cooled Breeder programs for many years. The experinece has demonstrated that test reactors serve a useful function to establish the design requirements and operating limits for individual fuel rods. However, there is important data that is not obtainable from irradiation tests. Only by operating a power reactor core under actual service conditions can data be obtained on the interaction of fuel elements, assemblies, and support structures and on the nuclear, thermal, and hydraulic performance of a reactor.

The currently planned operating life of the Shippingport light water breeder will slightly reduce the final fissile fuel loading compared to stopping core operation earlier, but it is still predicted to be more than the initial loading. Further, the ability to accurately determine breeding performance improves the longer the reactor operates.

The prime advantage obtained from continuing to operate the Shippingport light water breeder is that the total amount of energy potentially obtainable from thorium increases. Because this is an important aspect of reactor performance, DOE needs to learn how the core performs when operated for a long period.

Mrs. BOUQUARD. I notice in your statement you said the longer operation of the Shippingport core will provide a technical basis for operating to longer core life on any future cores that use uranium-233/thorium oxide fuel systems.

Now while this may be true, it is a requirement for the demonstration of the WCBR technology, and is it necessary or important to the eventual commercialization of this technology?

Admiral **Rickover**. Yes, because you're operating in a real powerplant, and that's what the industry is looking for. You can have all the experiments you want, and that will not convince people that you can do it in a real honest-to-God reactor. We're operating under real reactor central station conditions.

Mrs. **Bouquard**. You are demonstrating high burnup capabilities, but why can't this additional experience that you propose be gained by those who actually commercialize this concept, Admiral Rickover?

Admiral **Rickover**. They're not going to commercialize it if they don't know what they're going to get. You have to show them—we couldn't get industry interest in the Shippingport reactor in the first place. We never got any industry interest until after it worked very well.

When you have gone to the trouble and expense of assembling a team and building a reactor that works, you should get the most you can out of it. Furthermore, as I mentioned a moment earlier, where you have a source of energy, even if today it costs money to get it out, you'd better get it out now, because it's going to be much more expensive later on. You'd better learn now what you can get out. That's a philosophical aspect.

Mrs. **Bouquard**. But continuation of the WCBR program, Admiral, for an additional 3 years of burnup will potentially add another $200 million in additional cost to this project.

Now during this time, as you realize, we're under very severe budget constraints, and the very existence of some other nuclear program technologies may be threatened because of the lack of funds.

How can we continue to justify this expense, and how do you weigh the minimal advantages that can be gained from this at this time for the 3 more years of operation?

Admiral **Rickover**. First, I don't know of any other programs that are being threatened by it. I think every program that has merit is being financed by your committee.

But I get back to the other thing. Once you start something like this, you'd better find out what you can eke out of it. For example, you mentioned it's uneconomic. I don't think any energy that you can get in 1981 at 1981 prices is uneconomical. I think you must look at energy as a much more important source than just looking at today's economics.

We're not running that reactor because we lack power today, even though it's important. We want to show what can be obtained so people throughout the country and throughout the world can find out what they can get out of it. That's what we've always done in this reactor.

Mrs. **Bouquard**. Admiral, do you feel this has higher priority than a high-temperature gas reactor?

Admiral **Rickover**. I have never said that. I think they all ought to be done. I think you'll notice in my statement that I support pursuit of energy alternatives. If Congress doesn't have money to support my LWBR program, if you don't think this is important, you ought to knock the whole thing off.

Really, if you want to face the issue, decide to terminate the whole program. That's OK by me.

Mrs. Bouquard. Thank you.

Admiral Rickover. That's a decision you have to make.

Mrs. Bouquard. Thank you. Mr. Lujan?

Mr. Lujan. Thank you, Madame Chairman.

Mr. Lujan. Admiral, over the years I have served on these various committees from our old days on the Joint Committee on Atomic Energy. In those days I have always felt that your program has been one of the real contributions. Yours has been a real contribution to the energy needs of this country.

Admiral Rickover. You will remember, sir, that the same objections that are being made today were made at that time. The very same objections.

Mr. Lujan. Perhaps that brings us to the point that at the time this program was authorized it was authorized for proof of breeding, and in your statement you say the core will be shipped to the Naval Reactor's Expended Core Facility in Idaho to verify the performance. I suppose the question is, when?

Admiral Rickover. I can answer that question. We must find out first what is the maximum we can get out of it.

Mr. Lujan. I thought that was the purpose of the 3-year experiment and now it has slipped to 8 years rather than 3 years of trying to find that out.

Admiral Rickover. The reason the 3 years was mentioned at that time was because that was most we felt we could get. The committee would have liked it far better at that time if I said it was 8 years or 10 years or 15 years.

Mr. Lujan. But at the moment you don't know even if it's self-sustaining, much less what the breeding ratio is?

Admiral Rickover. No, sir. We would not be able to tell definitely until we actually examine it. But, it's extremely important to find out what is the maximum amount of energy we can get out of fissionable material. That's equally important because you have lots of powerplants that are running for short periods of time. Now, once they load up with fuel, then it gets to be waste material. We're trying to keep the nuclear waste at a minimum, too.

Mr. Lujan. Exactly, and I understand that. But the whole program—and you haven't addressed that—the proof of the breeding aspect of the program has not been addressed at all. You are moving to other areas.

Admiral Rickover. Now, we will address the proof of breeding as soon as we finish operating the core. But we find we can run the core longer. That's far more important because then you have a much better base on which to found a breeder program when you know what the maximum you can do, whether you use this system or you use some other system. The important thing, as I see it, is to get the maximum use you can get out of this fissionable material, which is the most valuable raw material we have in the world.

Mr. Lujan. We can't find that in any other reactor, just an ordinary light water reactor? The Idaho——

Admiral RICKOVER. The commercial ones only last for about 3 years. They're so designed.

Mr. LUJAN. How long——

Admiral RICKOVER. This would last 8 years. And my object would be to show that you could run the whole commercial industry on a different basis.

Mr. LUJAN. Do you really think the commercial industry is going to be interested in this when you haven't had that——

Admiral RICKOVER. No, sir. They're not. The commercial industry is interested only in making money.

Mr. LUJAN. But it's a far more complicated system than fueling one where you don't have to have the prebreeding.

Admiral RICKOVER. It's not any more difficult to operate.

Mr. LUJAN. I understand that, but it's more expensive to get to your fuel because of the prebreeding.

Admiral RICKOVER. But the point is, it's very difficult for people to separate value from money. How much did you value your wife when you met her? Could you put it in terms of money?

Mr. LUJAN. Not quite as much as I do now.

Admiral RICKOVER. Well, you made a good bargain. You invested wisely. You cannot, with anything like energy, try to put a current price on it. You can't do it, because it's the most valuable material resource we have. You've got to find out some time what are the potentialities. You have a chance here which you don't have anywhere else.

Mr. LUJAN. What about moving along in technology for the prebreeding fuel. Are you moving along in that? Is the technology there to develop that prebreeding fuel for use in those reactors?

Admiral RICKOVER. Yes; we are doing that.

Mr. LUJAN. Where is——

Admiral RICKOVER. In our advanced water breeder applications program, which is in the program we're presenting here today. We want to do that.

Mr. LUJAN. The program started, what, in 1977?

Admiral RICKOVER. No, it started before. It started in—it started in 1965.

Mr. LUJAN. 1965. The projected costs at that time to prove your point were $91 million?

Admiral RICKOVER. And it's much more than that now.

Mr. LUJAN. It's $118 million.

Admiral RICKOVER. We didn't know what we were getting into. You could take any viable and growing program in this country anywhere, a man starts out to do a certain thing but if he finds out he can do more, it's going to cost more money. You find that the fuel lasts longer, so you run the plant longer. That's inherent in any development program. No one can say when he stops development. I'm constantly being pressed, well, you only said so much money back 15 years ago. We didn't know what we were going to run into 15 years ago.

Mr. LUJAN. We have the same thing in all our programs. Right before you came we were talking about the liquid metal fast breeder reactor. It started at some $600 million and we're talking about $3 billion now. It seems like all these programs just keep going on and on.

Admiral **Rickover**. Any development program will invariably cost more than the man says, not because he's trying to fool you, he himself doesn't know what's going to come out of it. What if you will decide to have one child and you have sextuplets. It's going to be a hell of a lot more expensive than what you originally figured on. You might not have had that one if you figured it out.

Mr. **Lujan**. The bottom line to this for those $200 million, the $200 million for extending the program, what specifically would you find out that you do not know now?

Admiral **Rickover**. We will find out first whether it really breeds and how much we can get out of it. We don't know. If we don't do it, somebody else is going to have to go through the whole system all over again and do the same thing.

Mr. **Lujan**. But, Admiral, you're not going to find out if it breeds or not because you're not ready to take out the core and take it down to the testing in Idaho, you're going to continue to run it for 3 more years, or are you going to interrupt it in the next week or two to take it over to Idaho——

Admiral **Rickover**. The more we run a core, the better our information and more accurate and positive it will be.

Mr. **Lujan**. So you're going to postpone for another few years the proof of breeding.

Admiral **Rickover**. If it lasts longer than that I would recommend we keep on going. I'm talking now as an engineer who feels responsible for the whole future of the nuclear energy program. That's what I would do. If I find out that it will last longer, I would run it longer to find out what we can do with this material. That's the most important information we're going to get out of it.

Mr. **Lujan**. So why extend it? Why not provide your proof of breeding, which is where the program started?

Admiral **Rickover**. No, sir. You cannot——

Mr. **Lujan**. The mission has changed.

Admiral **Rickover**. You cannot tell in any kind of test except real running what a practical reactor will do. You cannot do that. At least I don't know how to do that.

Mr. **Lujan**. You mean how long the fuel will last?

Admiral **Rickover**. I want to get as much as I can out of this fuel.

Mr. **Lujan**. And that's very commendable, and I think that's very good, but the mission of the program has changed from your original thought of proof of breeding to how long the fuel will last.

Admiral **Rickover**. Because we see we can get more out of it, and that's true of any development, sir. You have it in weapons, also. You have the very same thing. You wouldn't argue against developing weapons, would you?

Mr. **Lujan**. It depends on the weapon; it depends on the cost. I would argue against the MX.

Admiral **Rickover**. I'm no expert on the MX and I can't express any opinion, but I know anything that's weapons gets unusual consideration because you can always cry wolf. I can't cry wolf. I can't do that. I have to stand on the technical merits. I have no particular interest personally running it any longer. I don't care if the committee decides, in its wisdom, to stop it; so be it. I'll do the best I can. And if you people in your wisdom, you're the elected representatives of the people, if you think you can exercise better judgment than I can, go ahead and do it. It's your legal right. I take no umbrage.

Mr. LUJAN. But what you are doing is testing the burnup, and my understanding, and I don't have the technical capabilities that you have, but my understanding is that it can be done less expensively in light water reactors.

Admiral RICKOVER. I don't agree with that. No, sir. If I did I wouldn't do this. Look, I am responsible for about 40 to 45 percent of all the combatant vessels in the U.S. Navy for their design and operation. Believe me, I have plenty to do. If I didn't think this was a worthwhile effort, do you think I would devote my energy to something like this? But I think this is ever more important than the naval vessels. The naval vessels furnish a transitory benefit. This is going to be of long-range benefit to the people of the United States. That's all that motivates me.

And, I say again, if you don't agree with it, cut it off.

Mr. LUJAN. No, certainly, we don't—at least I, nor do I believe anyone else questions the motives, questions that you are a very dedicated individual in the field that you are. You've proved it with the things that you've done.

Admiral RICKOVER. Well, if you think that I'm wrong, it's your wisdom to stop it.

Mr. LUJAN. We're trying to find out. That's the purpose of hearings.

Mr. FOSTER. Sir, if I might, there's one point that might help put this in perspective, that we felt the GAO, in their draft report, had not recognized properly.

The first is that according to the calculations to the extent that you can collect data during the reactor operation, this core is breeding. The proof of breeding that Admiral Rickover had proposed in his program is something that other people have not done, which is not just to calculate breeding potential, but to take the core out and physically measure it and know exactly how much. That's a step further than other people have done.

The next point is that he set out with the design objective of getting a core that would both breed and operate 15,000 hours. He has ended up with a core that has operated 20,000 hours already. It looks like the core might be able to go to 30,000 hours, which somehow gets characterized as being an overrun, a delay in the program, and so on, in going ahead and operating.

The fact that you can operate that core to that length of time and still breed would be an item of significant interest should somebody decide to implement it.

Mr. LUJAN. Even if it wasn't breeding, the fact that you could run it that length of time——

Admiral RICKOVER. That's right, but you see, I look at it as a conservation engineer. Here I'm using up this rare material, uranium; if I can get three or four times as much out of it as anyone else ever got, I've got to prove that. That is by far the most important thing I can do right now, and I don't want to be penalized for doing it. That's exactly what the attitude is, you haven't done what you said you would. No one who has ever developed a worthwhile thing has ever done the thing in the same kind of time. He wasn't trying to fool people. He didn't know.

Mr. **Lujan**. My time is up.

Mrs. **Bouquard**. Thank you very much. Mr. Volkmer?

Admiral **Rickover**. I would like to read something. Here's what I said to the Joint Committee on Atomic Energy, that was in 1966, concerning the thorium/uranium-233 fuel question. I said to the Joint Committee during a discussion on reprograming that:

> This is a development project. If I could tell you exactly what would happen in the future, it would not be developmental. All that we can do is use the best judgment we have, and from the lessons we see developing, express an opinion or judgment. It is my judgment that this is a good concept and can be made to work.

I was faced with the very same discussion we are now having. I exceeded what I said I would do at that time. You must use your best judgment when setting goals. And if you do exceed your goal, take advantage of it. That's all I'm saying.

Mrs. **Bouquard**. Gentlemen, for us to finish our hearings at our 4:30 deadline, we will have to limit questions to 5 minutes.

Mr. **Volkmer**. I'm Congressman Volkmer.

What would be the minimum amount that you would need for the next year? The minimum?

Admiral **Rickover**. $58 million.

Mr. **Volkmer**. $58 million. Then let's say that your core continues to go and we go into 1983. How much more would you need, approximately in 1983?

Mr. **Foster**. Sir, I don't have the exact figure here, but there is an important calculation. We figured for the GAO that the incremental cost of continuing to operate the Shippingport core instead of pulling it out as quickly as you could, as they proposed, would be about $20 to $25 million per year. It's not $200 million.

Admiral **Rickover**. $200 million has been quoted by GAO. It's not that bad.

Mr. **Volkmer**. What would be the total cost for the breeder fuel and everything, everything in case you went through 1983?

Admiral **Rickover**. In fiscal 1983, $56; in 1984, $56; in 1985, $55; in 1986, $51. Million, that is assuming shutdown late in 1982.

Mr. **Volkmer**. Now, assuming that the core begins to deteriorate and you do not get the output, say, by 1983, some time in 1983.

Admiral **Rickover**. We'd stop it earlier.

Mr. **Volkmer**. You'd stop it?

Admiral **Rickover**. Yes, sir, we'd stop it earlier. There's no point to running it after that. But this is a rare opportunity. It's the first reactor in the United States to use the uranium-233/thorium fuel.

Mr. **Volkmer**. These are the maximums that you would have to have or minimums, either way? You could operate on these amounts?

Admiral **Rickover**. Yes, sir.

Mr. **Volkmer**. And what would be the difference, tell me what would be the difference if we cut you off next year? I'm not asking money now. If we cut you off next year as between, let's say, 1984 or 1985, if we cut you off or you cut yourself off because the core deteriorates, all right? Now, what's the difference in knowledge?

Admiral **Rickover**. Well, there's a considerable difference in knowledge because this is the only reactor of this type that has ever operated for any long period of time, and if you take—you're talking about a rare material. You'd better find out as soon as you can what it can do.

Mr. VOLKMER. How long have you run it so far? 20,000 hours?

Admiral RICKOVER. Yes, 20,000 hours.

Mr. VOLKMER. You think you can go 30,000?

Admiral RICKOVER. Yes, sir, I hope so, anyway.

Mr. VOLKMER. A normal core presently in a light water breeder reactor will go somewhere around what, 3000, 4?

Admiral RICKOVER. The normal central station reactor operates about 3 years. So, you see the potential you have in this.

Mr. VOLKMER. Yes, I do, and I would hate to waste it. I would hate to waste it. That's what I see in many other things.

Admiral RICKOVER. We can't speed it up, because we don't have a way of dissipating the energy any faster.

Mr. VOLKMER. I see the same thing, I see a coal plant in Catlettsburg, Ky., built to produce liquid coal running tests, and the Department says we're not going to give them money, we're going to shut them down. We're talking about a total of $58 million, is that right?

Admiral RICKOVER. For a year.

Mr. FOSTER. The other point, sir, is that many of those costs, even if you ordered him to take the core out today, in those costs you still have to do the proof of breeding, take the core out and so on. So the incremental costs would be about $25 million a year to continue it.

Mr. VOLKMER. And these could be used or could they not be used in present or future constructed light water breeder reactors?

Admiral RICKOVER. Yes, that's one significant point I'm glad you brought out. They can be designed to fit into existing pressure vessels. It's not exactly the same design. You could build them to fit any pressure vessel, but you can do that. I'm glad you mentioned that point. The Shippingport LWBR was designed that way.

Mr. VOLKMER. One other point I think perhaps is somewhat of the problem with your whole concept as it relates to some of the other people in the nuclear industry.

Correct me if I'm wrong, under your concept when you are finished, there's very little residue, correct?

Admiral RICKOVER. There is radioactive waste left. The amount of radioactive waste depends on how long you run the thing, but if you run the reactor twice as long, it's concentrated instead of having it twice, you have it once.

Mrs. BOUQUARD. Mr. Volkmer, time is up.

Mr. VOLKMER. May I ask one last question?

Mrs. BOUQUARD. Yes.

Mr. VOLKMER. Will there be recyclable fuel from your core when it is proofed?

Admiral RICKOVER. Yes, sir, there will be enough for another core. It's important to run it while you can; that is, in the overall economic aspect it is far better to run as long as possible.

Mr. VOLKMER. If you used it all up and there was no recyclable fuel——

Admiral **Rickover**. You can recover it. Yes, there's plenty left over to recover. You would have to do that if you were breeding it, regardless.

Mr. **Volkmer**. Thank you.

Mrs. **Bouquard**. Thank you very much, Mr. Volkmer.

Mr. Wolpe.

Mr. **Wolpe**. Thank you, Madam Chairman.

I just want to first clarify the numbers here. It was our understanding what was requested was $200 million for 3 years of operation of the Shippingport reactor.

Now, what I hear you saying today—that is the extension of the program to carry this forward for those 3 additional years, would involve a cost of $200 million. Is that accurate or not, so at least we're talking about the same numbers?

Mr. **Foster**. Sir, may I clarify that? I think that is the total cost, the figures you are looking at are roughly the total cost of our civilian program request, our water cooled breeder program. That consists of the operating costs at Shippingport, what we call the LWBR effort, the R. & D., the proof of breeding, and so on that goes on with the reactor that's in Shippingport, and $19 million a year, roughly, for the advanced water breeder applications program, which is taking the existing technology and solving other relevant technology problems for a next generation or pre-breeder. And that is what Mr. Lujan was talking about.

Mr. **Wolpe**. So that we are on target, there is no conflict between the understanding of the request and that of the staff of our committee?

Dr. **Dugan**. The request for fiscal year 1982 is $58 million, and that contains $19 for the——

Mrs. **Bouquard**. 58 million is the total for 1 year. The $200 is for the 3-year program.

Mr. **Wolpe**. OK.

Admiral, in the body of your testimony there's a discussion about the criteria upon which one ought to make judgments as to where to place our Federal R. & D. funds. And you have this passage here that talks about—and I quote:

> Until there is an adequate technology base to demonstrate the practicability, it's a waste of time to try to compare the relative costs of commercializing various alternatives. I doubt you can find any nuclear power cost comparison studies done 10 or 20 years ago that are worth the paper they're written on. If anything, the energy future is more unpredictable today than it was 20 years ago.

Now, my question is: If you do not attempt to assess the potential commercial feasibility of a given technology, if that's not an appropriate basis upon which to base our judgments, what is? What are the specific criteria that you would advance?

Admiral **Rickover**. I think the best way I can answer that is an article I've published—I'll read one page—in the June 1953 issue of the Journal of Reactor Science and Technology:

> Important decisions relative to the future development of atomic power must frequently be made by people who do not necessarily have an intimate knowledge of the technical aspects of reactors.

That may well be true right here.

> These people are, nonetheless, interested in what a reactor plant will do, how much it will cost, how long it will take to build, and how long and how well it will operate. When they attempt to learn these things, they become aware of confusion

existing in the reactor business. There appears to be unresolved conflict on almost every issue that arises.

I believe this confusion stems from a failure to distinguish between the academic and the practical. These apparent conflicts can usually be explained only when the various aspects of the issue are resolved into their academic and practical components. To aid in this resolution, it is possible to define in a general way those characteristics which distinguish the one from the other.

An academic reactor or reactor plant almost always has the following basic characteristics: It is simple. It is small. It is cheap. It is light. It can be built quickly. It's very flexible in purpose. It's an omnibus reactor, very little development is required. It will use mostly off-the-shelf components. The reactor is in the study phase; it is not being built now.

On the other hand, a practical reactor plant can be distinguished by the following characteristics: It is being built now. It is behind schedule. It is requiring an immense amount of development on apparently trivial items; corrosion, in particular, is a problem. It is very expensive. It takes a long time to build because of the engineering developmental problems. It is large. It is heavy. It is complicated. The academic reactor designer is a dilettante.

Unfortunately for those who must make far-reaching decisions without the benefit of an intimate knowledge of reactor technology, and unfortunately for the interested public, it is much easier to get the academic side of an issue than a practical side. For a large part, those involved with the academic reactors have more inclination and time to present their ideas and reports orally to those who will listen——

Mr. **Wolpe**. Admiral, could I interrupt you just for a moment, because we don't—I'm afraid my time, I'm informed, is very limited. And I wonder if we could—first of all, I have a couple of additional questions, but I would like permission perhaps, given the limitations on time, to submit some written questions to you.

Admiral **Rickover**. I thought I was giving you some philosophy, but we'll put the philosophy in the record.

[The information follows:]

## EDITORIAL

From

The Journal of Reactor Science and Technology, Volume 3, No. 3

Important decisions relative to the future development of atomic power must frequently be made by people who do not necessarily have an intimate knowledge of the technical aspects of reactors. These people are, nonetheless, interested in what a reactor plant will do, how much it will cost, how long it will take to build, and how long and how well it will operate. When they attempt to learn these things, they become aware of confusion existing in the reactor business. There appears to be unresolved conflict on almost every issue that arises.

I believe that this confusion stems from a failure to distinguish between the academic and the practical. These apparent conflicts can usually be explained only when the various aspects of the issue are resolved into their academic and practical components. To aid in this resolution, it is possible to define in a general way those characteristics which distinguish the one from the other.

An academic reactor or reactor plant almost always has the following basic characteristics:

1. It is simple.
2. It is small.
3. It is cheap.
4. It is light.
5. It can be built very quickly.
6. It is very flexible in purpose ("omnibus reactor")
7. Very little development is required. It will use mostly "off-the-shelf" components.
8. The reactor is in the study phase. It is not being built now.

On the other hand, a practical reactor plant can be distinguished by the following characteristics:

1. It is being built now.
2. It is behind schedule.
3. It is requiring an immense amount of development on apparently trivial items. Corrosion, in particular, is a problem.
4. It is very expensive.
5. It takes a long time to build because of the engineering development problems.

## EDITORIAL

6. It is large.

7. It is heavy.

8. It is complicated.

A common example can be given to indicate the application of the above generalities:

A fairly conventional academic power reactor might use natural or slightly enriched uranium rods in which the burn-up is a minimum of 10,000 mwd/ton. The fission products are confined to the fuel element by a simple cladding technique. The elements operate in high pressure water at 600°F.

In the practical reactor, difficulties are encountered. No element of the above type has been carried to more than 4000 mwd/ton. Eight years of work at Hanford and related laboratories have failed to produce a cladding technique which gives really satisfactory performance in water at 200°F. At 600°F uranium reacts violently when exposed to water. The Chalk River experience shows the difficulty of maintaining a plant in which some fission products have escaped.

The tools of the academic-reactor designer are a piece of paper and a pencil with an eraser. If a mistake is made, it can always be erased and changed. If the practical-reactor designer errs, he wears the mistake around his neck; it cannot be erased. Everyone can see it.

The academic-reactor designer is a dilettante. He has not had to assume any real responsibility in connection with his projects. He is free to luxuriate in elegant ideas, the practical shortcomings of which can be relegated to the category of "mere technical details." The practical-reactor designer must live with these same technical details. Although recalcitrant and awkward, they must be solved and cannot be put off until tomorrow. Their solutions require manpower, time, and money.

Unfortunately for those who must make far-reaching decisions without the benefit of an intimate knowledge of reactor technology and unfortunately for the interested public, it is much easier to get the academic side of an issue than the practical side. For a large part those involved with the academic reactors have more inclination and time to present their ideas in reports and orally to those who will listen. Since they are innocently unaware of the real but hidden difficulties of their plans, they speak with great facility and confidence. Those involved with practical reactors, humbled by their experiences, speak less and worry more.

Yet it is incumbent on those in high places to make wise decisions, and it is reasonable and important that the public be correctly informed. It is consequently incumbent on all of us to state the facts as forthrightly as possible. Although it is probably impossible to have reactor ideas labeled as "practical" or "academic" by the authors, it is worth while for both the authors and the audience to bear in mind this distinction and to be guided thereby.

H. G. Rickover
Captain, USN

June 5, 1953

**Mrs. BOUQUARD.** Questions can be submitted.

**Mr. WOLPE.** Let me ask you a couple of brief ones—and I didn't mean to cut you off, other than the time constraints, because I would like to pursue the philosophical questions as well. But first of all, just a very specific one: If you extend the operation for 3 years, would you reduce the funding for the AWBA, the advanced water breeder application program, and the light water breeder reactor line items to minimize the increase in cost?

**Admiral RICKOVER.** What was the last question, sir?

**Mr. WOLPE.** If we were to extend the operation for 3 years, would there be a reduction in the funding for the advanced water breeder application?

**Admiral RICKOVER.** You mean if we slowed it down, would there be reduction?

**Mr. FOSTER.** I think the answer to that, Admiral, is yes, there will be some. We had planned some of the proof of breeding that would be put off for awhile. There would be some adjustments.

**Mr. WOLPE.** As part of the submission, would you indicate what part—precisely what will be reduced?

**Admiral RICKOVER.** You're not going to save money that way. All you do is delay it.

[Information to be furnished follows:]

### WATER COOLED BREEDER PROGRAM FUNDING PROJECTIONS

Funding projections based on operating the light water breeder reactor in the Shippingport Atomic Power Station for 32,500 Effective Full Power Hours are:

*Water cooled breeder program*

[In millions of dollars and at a 1982 dollar level]

| Fiscal years: | |
|---|---|
| 1982 | 58 |
| 1983 | 42 |
| 1984 | 44 |
| 1985 | 50 |
| 1986 | 51 |

The lower funding requirements for fiscal year 1983 and beyond result from deferring the end-of-life effort and documentation of that effort as well as some other Advanced Water Breeder Applications work due to operating the Shippingport plant for several more years.

**Mr. WOLPE.** Just to clarify it, there's another portion of your statement. Taken together, the three constituent parts in the water-cooled breeder program, shippingport, LWBR, and advanced water breeder applications will provide technology needed by those who must eventually decide energy alternatives. This information will already be available by the time liquid metal breeder is already operating——

**Admiral RICKOVER.** This information will be available from the liquid metal breeder?

**Mr. FOSTER.** The point is you can continue the operation of the shippingport LWBR as the Admiral has suggested, get the proof of breeding information back by the time Clinch River reactor is up and operating and people have firsthand experience there and firsthand experience here. In other words, this doesn't throw the LWBR behind the LMFBR in terms of whoever makes the decisions at that time having information on what can and cannot be done.

Admiral **Rickover**. I would like to put this in a very simple way. Theoretically, the liquid metal breeder is better, no question about it, because it breeds more. But if you're going to spend many years on developing a breeder, what if it doesn't live up to expectations and you have no other option? You're pretty bad off. Then you have to start in all over again.

So the money that you are spending gives you a choice. You certainly will have one, and you may have two.

The issue you have to face is this: Is it worth present dollars to do this thing for the future in energy? If you look at the history of energy in this country—particularly in the last 15, to 20 years—it unquestionably is. You're talking about piddling sums of money compared to what it means for the entire economy and the way of living we have in this country. That's the way I look at it.

I'd like to assure you once more I am not particularly interested, if the committee doesn't desire to do it, to fight this thing. Of course, it has to go to the Senate, but I'm not interested in carrying out any fight with this committee. I want to make that clear. Don't think that this is something that my life depends on. It does not.

Mr. **Wolpe**. Thank you.

We'll probably be giving you some additional questions for the record, and I thank you.

Mrs. **Bouquard**. Mr. Forsythe.

Mr. **Forsythe**. One minute left.

Mrs. **Bouquard**. You're the lucky one. I see you have your shamrock.

Mr. **Forsythe**. I'm not sure where that gets me.

I guess I really don't have a question, except for one, Admiral. Do any of these objectives include the shutdown costs that would happen if it was cut off?

Admiral **Rickover**. No, sir. But you will have that ultimately anyway.

Mr. **Forsythe**. Right. But what would they be? In other words, if we did not appropriate for fiscal 1982, it would be shutdown costs. What would they be? They're not included.

Admiral **Rickover**. There is another group Mr. Foster says—it is true, a separate group in the Department of Energy is responsible for that aspect. I am not.

Mr. **Forsythe**. This would not come into that?

Mr. **Foster**. That's the decommissioning.

Admiral **Rickover**. It costs money, but that's another organization.

Mr. **Forsythe**. It can cost more to decommission than it does to operate. It's a significant number.

Admiral **Rickover**. You're going to have that significant number with any atomic powerplant.

Mr. **Forsythe**. We all agree. But the question, of course, is posed. Do we carry on, as you tried to point out, to get a lot more information?

Admiral **Rickover**. You can—and the way I'm suggesting will give you much more information.

Mr. **Forsythe**. We can wait for another—a couple of years.

Admiral **Rickover**. Yes, sir.

Mr. **Forsythe**. Thank you.

Mrs. **Bouquard**. Mr. Lujan.

Mr. **Lujan**. I know we're out of time, but I really have one question that is brought up by the GAO report, Admiral. They say we found by asking the utilities minimal substantial interest in pursuing the water-cooled breeder. However, if and when its breeding ability is confirmed, nuclear utilities may take a more active interest in developing the concept. In other words, they're not interested as long as you don't have the proof of breeding. But once you have the proof of breeding, that's really what they want to know. And why don't we have it?

Admiral **Rickover**. Why we don't have it yet?

Mr. **Lujan**. You can take it out and prove it.

Admiral **Rickover**. Well, if you think it's worth—look, I mentioned earlier—I don't know whether you were in the room at that time—the utility industry has never showed a financial interest even in the first reactor we had, the first powerplant. They were all enthusiastic, but never gave it a dollar toward the research and development.

Mr. **Lujan**. But they're now interested in will it breed. It is shown that if it will breed their interest will rise.

Admiral **Rickover**. But it will be of far greater value to the utility industry from a financial standpoint to find out how long the thing can last and operate.

Mr. **Foster**. One other thing is we don't honestly believe that somebody would commit to the LWBR with the LMFBR in the wings as a potential for the future and looking more promising from a breeding standpoint. We disagree with GAO. If you told industry today that the LWBR bred, they would not do a darn thing until they knew where reprocessing came out, how disposition of radioactive material will be handled, and how well the LMFBR works. So their urgency in getting this dope out we feel is a red herring.

Admiral **Rickover**. You are talking about the most backward industry in the United States. I have had experience with those so-and-so's for 25 years.

Once they claimed we didn't send the information out. They went to the Atomic Energy Commission and said we didn't issue reports. And we broke out—we finally found them in the company's library. They had never opened one. They were still in the wrapper, for many years. But they claimed we weren't handing the stuff out.

Mrs. **Bouquard**. Admiral, I believe we've run out of time.

I would like to recognize the presence of one of our new members, Congressman Lowery of California. He is certainly a valuable member of this committee, and I'm sure that he will also have additional questions, without objection, to submit to you in writing.

We thank you for your testimony today, for your contribution to our hearings.

The subcommittee will meet tomorrow in room 2247, from 2 to 5 p.m., where we will hear witnesses in reference to our magnetic fusion program.

If there is no further business, the committee stands adjourned.

Admiral **Rickover**. I do want to thank you for your courtesy and thank all the other members for their courtesy. It has been a pleasure talking to you.

[Whereupon, at 4:35 p.m., the hearing was adjourned, to reconvene at 2 p.m., Wednesday, March 18, 1981.]

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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## WEDNESDAY, MARCH 18, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 2 p.m., in room 2247, Rayburn House Office Building, Hon. Marilyn L. Bouquard (chairman of the subcommittee) presiding.

Mrs. Bouquard. The hearing will come to order.

Today's hearing will be with Department of Energy officials on the topic of magnetic fusion energy program. As a reminder, I will note that we have already had two previous hearings on magnetic fusion. On February 25, 1981, we heard from the Department of Energy and, on March 3, 1981, we received testimony from non-Government witnesses representing industry and the universities.

In the testimony on February 25, the Department indicated it had no intention, at this time, of proceeding with the Center for Fusion Engineering and the fusion engineering device. They contended that the reasons had little to do with the technical ability or readiness of the program to proceed, but rather the Department wished to reduce its future year spending obligations, and that the new aggressive push for nuclear fission made the development of fusion less urgent. I personally can understand the desire to reduce expenditures. However, I do disagree in the strongest way possible with the belief that the development of fusion is less urgent at this time.

Our non-Government witnesses testified to the readiness of industry to become involved in a major way in the development of fusion energy. They noted that, after 1984-85, there appears to be no further commitment on the Government's part to fusion development, and this makes it difficult to plan for adequate industrial capability to be present.

So we must chart a steady course for the fusion program within the pressures of budget constraints.

Today we will explore in more detail the progress in the fusion program. We believe strongly in following the intent of the fusion law and we, therefore, may have a slightly different set of priorities than does the Department. We need to find out today, in as clear and concise a manner as possible, the reasons for the Department's fiscal year 1981 recissions and fiscal year 1982 project cancellations and how these decisions affect the overall health of the fusion energy program.

Our first witness today will be Dr. N. Douglas Pewitt. He is Acting Director of the Office of Energy Research at the Department of Energy. After Dr. Pewitt, we will hear from Dr. Kintner, the Director of the Office of Fusion Energy, who manages the U.S. fusion programs.

Dr. Pewitt, without objection, we will place your formal written statement in the record, and you may proceed as you wish.

## STATEMENT OF N. DOUGLAS PEWITT, ACTING DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY

Dr. **Pewitt**. Thank you, Mrs. Chairman. It is quite an honor to have an opportunity to appear before you twice to discuss the fusion program and, finally, to be able to discuss in more detail with you our fiscal year 1982 budget request. Dr. Kintner is with me to provide you more the details. I thought I would focus more on the Department's policy with regard to fusion. I might add that the development policy is of a dynamic process. I think what I have to say today is somewhat more positive than what I had to say while we were still in the process of formulating the budget.

As I noted in my earlier testimony, a number of recent accomplishments have led to increased confidence in the ability of the fusion process to produce a burning plasma using magnetic confinement techniques. The progress of magnetic fusion has been so rapid that there is a broad consensus that magnetic fusion is technically ready to enter into an engineering development phase.

The new strategy involves the conduct of a broad-based program along two concurrent lines. The first line is scientific investigation involving two principal goals: The resolution of remaining scientific uncertainties crucial to the achievement of the burning plasma objective, and development of reactor concepts that offer characteristics attractive for power generation. A second line of engineering effort aimed at developing experience with practical problems of creating and maintaining burning plasma is a new addition to the program. The synthesis of these two lines is intended to demonstrate fusion's engineering feasibility and will lay the basis for a national assessment of "fusion's highest potential."

The fiscal year 1982 budget request of $460 million provides for increased emphasis directed toward resolving many of the complex engineering problems that remain. Our expectations are high that these problems can be surmounted, although the effort will take time and will be expensive.

The proposed fiscal year 1982 program is in general agreement with several external reviews, and is not inconsistent with the intent of the Magnetic Fusion Engineering Act. However, as mentioned earlier, the Administration will not make a formal commitment to proceed with a fusion engineering device until after careful and complete review of the ramifications.

The Department is enthusiastic and committed to the program's engineering efforts, and the Secretary has expressed repeatedly, in testimony and in public, his support for the magnetic fusion program. The Department is committed in fiscal year 1982 to a vigorous program embarking on an engineering development phase. The proposed fiscal year 1982 budget is evidence of that commitment. The $460 million request is a 19 percent increase over the

Reagan administration's proposed 1981 level of $382.8 million—this at a time when many technology programs of the Department are being severely reduced in an effort to solve the Nation's economic problems.

This increase will allow for exploratory studies and initial design activities aimed toward the successful operation of a fusion engineering device. More definite conceptual design, along with improved engineering R. & D. plans will sharpen our understanding of the mission and scope of the FED and permit improved planning and cost estimates for the engineering phase of fusion development. Without this effort, we might face a range of problems that could inhibit the future success of the program.

In formulation of the fiscal year 1983 budget, the administration will very carefully consider all factors related to the timing and pace of the fusion program and, in particular, the commitment to a multiyear, billion dollar investment, such as the FED. In light of the administration's redirection of energy programs and efforts to resolve the nation's economic problems, this period of review is not only necessary but reasonable. The 1982 budget increase, the commitment to engineering development and the desire to base long-term major funding commitments on a thorough understanding of where these commitments fit into the Nation's energy and economic picture, is a very positive indication of strong support.

This concludes my summary of my prepared remarks. Thank you.

[The prepared statement of Dr. Pewitt follows:]

Statement of N. Douglas Pewitt
Acting Director
Office of Energy Research
Department of Energy
Before the
Energy Research and Production Subcommittee
of the House Committee on Science and Technology

March 18, 1981

Madam Chairman and Members of the Subcommittee:

It is an honor to appear before this Subcommittee again to discuss the FY 1982 budget request for Magnetic Fusion Energy in more detail than was possible during my February 25, 1981 appearance. My introductory statement will focus on the Department's policy on the fusion program. I am accompanied by Dr. Edwin E. Kinter who will discuss the details of the proposed FY 1982 budget.

As I noted in my earlier testimony, a number of recent accomplishments in experimental and theoretical work have lead to increased confidence in our ability to produce a burning plasma using magnetic confinement techniques. In other words, we are making rapid progress toward our goal of determining whether fusion's many benefits can be made available to future generations. In fact, the progress of magnetic fusion research during the past few years has been so rapid that the program is now technically ready to enter the engineering development phase.

The program's strategy involves the conduct of a broad based program along two concurrent lines of investigation. One line is the engineering effort aimed at developing experience with the practical problems of creating and maintaining a burning plasma. The Fusion Engineering

Device (FED) would become a central element of this effort. The second line is one of scientific investigation involving two principal goals: (1) resolution of those remaining technical uncertainties crucial to the achievement of the burning plasma objective and (2) development of reactor concepts that promise better characteristics than projected for current concepts. The synthesis of these two efforts is intended to demonstrate fusion's engineering feasibility and lay the basis for a national assessment of "fusion's highest potential." A positive assessment would lead to a commitment to the operation of a utility-size energy producing system.

The FY 1982 budget request of $460 million for the program will allow us to make what we hope will be continued rapid progress toward resolving the many complex engineering problems that must be addressed. Our expectations are high that these problems can be surmounted, although the effort will take time and will be expensive.

Our proposed FY 1982 program is in agreement with the thrust of the conclusions of a number of external advisory groups, including the recent study of the Energy Research Advisory Board. As you know, that study envisioned an engineering development effort centered around a Fusion Engineering Device to address the major engineering design issues and a Center for Fusion Engineering which would pull together the various efforts related to engineering development and provide an overall management focus. Although the Department is not now prepared to commit to a definite date for operation of the FED, our proposed program for 1982 is not inconsistent with the intent of the Magnetic Fusion Engineering Act.

The Department is enthusiastic about and committed to the program's engineering efforts. The Secretary has repeatedly expressed his interest in and support for the magnetic fusion program. Our proposed FY 1982 budget is, in fact, evidence of this support. The $460 million proposed budget represents approximately a 15% increase over last year's budget at a time when almost all other technology and research programs are limited to a cost of living increase if, indeed, their budgets have not been reduced in an effort to help solve the Nation's economic problems.

This increase in FY 1982 will allow us to undertake exploratory study and initial design activities which will enable us to build and design and successfully operate an FED in the future. The FED concept is presently being defined through the determination of physics and engineering system parameters. In FY 1982, definitive conceptual designs can be undertaken on the FED systems, vacuum vessel, blanket systems and buildings. A more definitive conceptual design and cost estimate along with improved engineering R&D plans will substantially sharpen our understanding of the mission and scope of the FED and permit improved planning and cost estimates for the engineering phase of fusion development. Without a clear idea of the scope and cost of a facility such as the FED--one which is likely to cost in the range of a billion dollars--we no doubt would be faced with a whole range of problems that could seriously inhibit the future success of the effort.

The Department is committed in FY 1982 to a vigorous program which embarks on the engineering development phase. In the formulation of its FY 1983 budget, the new Administration will very carefully consider all of the factors related to the timing and pace of the fusion program and, in particular, the commitment to a multiyear, billion dollar investment such as the FED. In light of the new Administration's redirection of energy programs and efforts to resolve our economic problems, this period of review is not only necessary but reasonable. The FY 1982 budget increase, the commitment to engineering development and the desire to base long-term major funding commitments on a thorough understanding of where we are headed and where these commitments fit in the nation's energy and economic picture is, in my opinion, a very positive indication of strong support.

Madame Chairman, this concludes my comments. I will be pleased to respond to questions.

Mrs. BOUQUARD. Thank you, Dr. Pewitt, for your testimony.

Dr. Kintner, you may proceed.

## STATEMENT OF EDWIN E. KINTNER, ASSOCIATE DIRECTOR FOR FUSION ENERGY, OFFICE OF ENERGY RESEARCH, U.S. DEPARTMENT OF ENERGY

Dr. KINTNER. Thank you very much, Mrs. Bouquard.

A great deal has happened since we were last before this committee a year ago. I am glad to be able to bring you up to date in some detail on those matters that affect our 1982 budget request.

The objective of the magnetic fusion program in the Department of Energy is develop the highest potential of fusion. It is not to take what appears to be the shortest, quickest road to fusion power, but rather to find the best road, to investigate thoroughly an entirely new field of science and technology, so as to provide a base from which sound judgments can be made as to the most economical and practical way to use this ultimate energy resource—the last known physical process by which energy can be produced—the energy of the Sun and the stars.

There are a number of important reasons why we believe fusion should be developed as a base energy source. These include its widely available and easily obtained fuel, significant environmental advantages over combustion of fossil fuels or fission of uranium isotopes, and the potential for a broad range of applications, including process heat and synthetic fuel production, as well as fissile breeding.

In addition, for this Nation the development of fusion offers certain ancillary benefits. Fusion is a high-technology field in which the United States exerts recognized world leadership; the strength of the U.S. program is a measure of that continued leadership. A concomitant of that is that the actions of the U.S. are carefully watched at each decision point.

The European Community has established the equivalent of the Buchsbaum committee to review the future of fusion in Europe. The chairman of that committee is coming to the United States and will be with us next Monday to examine our program and its status and intent. I am sure that will have a significant influence on the future direction of the European program.

Moreover, fusion inspires development, both within the program itself in terms of the richness of ideas for fusion systems, and in a wide range of other scientific and technological areas in a way that no other energy program does. In this way, it offers the mechanism for advancing a number of technologies well beyond their present state and, therefore, provides the opportunity for spinoffs to industrial innovation. These areas include the entire field of plasma physics investigations, the development and application of superconductivity well beyond its present state, the research associated with advanced materials, the development of high frequency, high-power vacuum tubes, the design and operation of high-voltage, high-powered electrical equipment, and the application of new, more powerful computational techniques.

However, although less expensive than putting a man on the Moon, magnetic fusion is the longest term, and most expensive in human and material resources of any development program undertaken for purely civilian reasons. It is, therefore, a test of the ability of society and government to marshal the resources required for a commitment of this magnitude without direct military justification.

In fact, as you have heard in the previous testimony from Dr. Pewitt, the Department is now preparing to address the specific question of fusion's role in the future of U.S. energy supply; this question follows directly from the earlier determination of the fusion program's technical readiness to begin its engineering development phase.

Because some members of this committee are not familiar with fusion, I would like to take a few minutes to explain its fundamentals.

Mrs. BOUQUARD. Very good. Please proceed, Dr. Kintner.

Dr. KINTNER. It is really in principle very simple. It involves the combining of very light nuclei, in this case, deuterium and tritium. In that sense, it is the opposite of fission which involves the splitting of heavy nuclei. In both instances, mass is lost and converted to energy by the Einstein equation $E=mc^2$. But to cause this combination to occur, to cause fusion to occur, the light isotopes of hydrogen must be raised to extremely high temperatures, temperatures above 45 million degrees, well above the temperature in the center of the Sun. This is because temperature is a measure of velocity and these particles must strike each other extremely rapidly or they will not fuse. But, when we heat a gas in this way, the particles move more rapidly and, eventually, the electrons are set free from the nuclei and a plasma is formed. The plasma is simply a very high temperature gas. It is a mixture of electrons and ions. It continues to act as a gas and exert pressure on its surroundings;

but, if we try to confine it by material means, it will very quickly cool and lose the properties of a plasma.

One way in which it can be confined is by the use of magnetic field lines. The particles are charged, and charged particles tend to follow magnetic field lines exactly as iron filings do in in a high school physics experiment with a horseshoe magnet. So when we impress a magnetic field on these randomly moving particles in the plasma, they tend to be constrained to follow the field lines.

That is one way to make a fusion confinement device, but it would require a machine about 50 miles long to do so in any way which would produce useful energy. That is not very practical, so we must obtain some way to better confine the plasma than just applying magnetic fields.

There are two fundamental ways to do this; one is shown in the upper-right corner and that is to simply squeeze the bundle of magnetic field lines at the ends as you would a soft loaf of bread. That is called a magnetic mirror. Unfortunately, by doing it in that simple way, there is still such a loss at the ends that we cannot reach energy break-even. So in the magnetic mirror program, the effort is to find ways to close the ends—to plug the ends—of a magnetic mirror. That is the major objective in the mirror program at the moment.

We have succeeded in making the first and significant step in finding a way to close the ends of a mirror, that is the so-called tandem mirror experiment which has been conducted over the last 2 years at Livermore.

The next way in which plasma confinement can be improved is simply to bend the magnetic field lines back on themselves so that the particles continue to circulate around a toroid. When that toroid has a current applied to it, it improves the confinement and, when a current is circulating in the toroidal plasma, then we have a Tokamak. Those are the two major ways in which we are able to confine plasmas to such a degree that we can look forward to making significant quantities of useful power.

I think it would be worthwhile to take just a minute and talk about the history of fusion, because the history of fusion is indicative, I think, of what is promised. The research was first begun about 1950, at a time when success had been achieved rather easily, once the atomic bombs had been developed in making thermonuclear weapons. So there were great expectations that conversion of thermonuclear weapon research to practical uses of fusion would come quickly. But very soon after that, those expectations were killed, and a rude awakening took place because the plasmas tended to be highly unstable—in a gross sense—and it took a considerable period of time to straighten that one out. It was first hoped that we could confine a plasma from a gross sense and then smaller instabilities appeared and that led to further disillusionment to the point that the Atomic Energy Commission established a committee to review the program and almost stopped it completely. It was continued at a very low level and with very specific orientation. That lasted for 5 years.

The Soviets, however, developed a device called a Tokamak, simply taking a toroidal device and inducing a current flow through the plasma. They came to the United States to convince the people here that they were really able to do what they said they were doing. That changed the U. S. program orientation, and there was a very rapid increase in experimentation along the Tokamak line, which has been continuing ever since. Now we have reached the point where it is generally assumed throughout the scientific community that the scientific feasibility of fusion is established. That has just occurred in the last 2 or 3 years. However, it is accepted worldwide. I think that is a profound conclusion and a profound milestone in research associated with fusion.

What we are saying, and what the reviews which have taken place in the last year are saying, is that we can now turn ourself in the next decade to establishing the engineering feasibility of fusion.

We have been making rather rapid progress over the last few years, and that is shown on the next three viewgraphs. Here is a plot of the increases in temperature since 1955. The vertical axis increases in each one of those steps by a factor of 10, so it is a factor of a 1,000 difference between 1955 and what we are predicting we will be able to do in TFTR. PLT in 1978 and 1980 created plasma temperatures which were very, very close to those needed for reactor and above the minimum required to ignite a plasma.

The next viewgraph shows what has happened to another parameter—that of density times confinement time. These are the two major parameters which we look at in terms of feasibility.

As a matter of fact, just today, I had confirmed information regarding an experiment in the Frascati Tokamak just outside Rome, which has just recently increased that record of confinement time to a little over what Alcator reached. They have not yet reached the limits of their device, and they are very enthusiastic about moving farther up that curve.

So in both of these cases, significant progress has been made over a long time and it is continuing on an exponential basis.

This is summarized in the next viewgraph. I would like to point out here the axes of this plot. On the left axis, the vertical axis, is the quality of confinement; that is, the ability to confine the plasma. It is measured by the product of density times the insulating capability of the magnetic field.

On the horizontal axis is plotted the temperature of the plasma. You will see that, in each case, these plots—these axes—are exponential; that is, each one of the marks is a factor of 10 higher than the other.

The curved lines through the plot are measures of the energy efficiency; that is to say, the relationship of the energy produced in the plasma to the amount taken to heat it. You will see in the upper righthand corner we have the gain lines of 1,10 and then ignition, and these are the areas we need to operate in to make power reactors.

Now, we will show you how progress has been going in both the Tokamak area and then later in mirrors. The early Tokamaks operated in that block in the lower left corner when we were able to put a considerable amount of ohmic heating into them; that is, sufficient current flowed that we heated the plasma exactly like an electric range burner. Then we were able to get up to temperatures of about 1 to 1½ kiloelection volts (keV) or 15 million degrees.

In 1978 we started to inject significant amounts of auxiliary heating into the plasma. That began with the ORMAK at Oak Ridge. We are still continuing to use neutral beam heating significantly, and that has gotten us to the point where we have temperatures very close to 10 keV or 100 million degrees. The TFTR is projected to fall into the next block, beyond that, and we are now reasonably confident that it will, in fact, reach those criteria. So you see on this kind of a plot, also, there is a steady, positive, exponential progress.

The mirror program that has shown similar progress but has not had nearly as much effort included in it but, nevertheless, progress is also moving up the same kind of curve. The II-X project at the very bottom of the chart was operational in about 1974. Its modification II-X-2B was operational in 1977. TMX was operated last year, and we are in the process of building the MFTF-B, which you will see is very close to the TFTR parameters.

The next block shows you the area of the goal for the FED, which is to produce significant thermonuclear energy, sufficient that it can be used for serious engineering technology development.

I would like to point out that, during the last year, there have been four significant reviews of the program—very broad reviews. One, at the bottom, is by International Fusion Research Council, which included participation from Japan, the Soviet Union, and Western Europe. The Department of Energy's Energy Research Advisory Board made a very thorough review of the program. Your committee studied the program over a period of about 6 months and held a number of hearings, and the Atomic Industrial Forum established a study group.

All of these reviews came to essentially the same conclusions, which are that the program is ready to begin the engineering feasibility stage of fusion.

The Energy Research Advisory Board panel, in particular, endorsed the program quite favorably, as you can see from these remarks. I would like to point out that this was one of the most distinguished scientific panels ever assembled. It included the vice president of Bell Telephone laboratories; it included the former Administrator of NASA; it included John Foster, who was for 7 years the head of research and development in the Department of Defense; it included the president of CalTech; and the director of the Stanford Linear Accelerator Center. Now this group met for about 3 months; visited all the sites—the major sites in the program—and arrived at a unanimous conclusion which is summarized on that previous viewgraph.

Now I would like to talk about the internal logic of the program for a minute. The primary effort is on the toroidal system, especially the Tokamak, because this system already provides plasma characteristics very close to power reactor conditions, and we are able to study plasma physics in that region with the Tokamak in a way we cannot in any other system of confinement.

We have a strong secondary effort in the linear systems, especially in the mirrors and the Elmo Bumpy Toruses and, as I said, the mirror program is making significant progress and, by the time we have MFTF-B operational, we will have, we believe, a highly competitive situation between these two major efforts.

The technology effort, too, has two major objectives. The first one is to provide the technologies we require to continue more powerful physics experiments. The second is to do additional research which provides information on which we can make judgments and decide directions for research for power reactors beyond the experimental reactor program we now have.

One of the things I have mentioned in previous testimony to this committee and one of the important aspects of the program, is that magnetic fusion has been a very international activity. The scientists working in fusion worldwide have had the sense that they are doing something that is extra international; that is, there are no immediate defense or proprietary interests and what they are doing is important for mankind not simply individual nations.

There are four major blocs participating in these international programs—the United States, the Soviet Union, the European community, and Japan—and we have estimated a total professional manpower on that chart. The Soviet Union is, we believe, expending more professional manpower, but it is not making the progress the United States is making because, first of all, the program is not as focused as ours and, second, they have not made in recent years the expenditures on the large devices like TFTR required to carry the program into new plasma research regions. Nevertheless, the USSR's program is strong. It has contributed a great deal to the advanced state of the field, but, again, for obvious reasons, our cooperation with the Soviets, which was very strong 2 or 3 years ago, has been seriously reduced as a result of the recent stiffening of the international relationships between the Soviet Union and the United States. On the other hand, the relationships with Japan have been strengthened significantly. The Japanese program continues to grow, and our working relationships with Japan have increased accordingly.

We have only about one-third of the total world effort in magnetic fusion, but our leadership is important because it provides a basis for synergism of world efforts, and we are trying to use our leadership to cause that synergism to take place.

Now let me speak for a minute to the institutional structure of the program here in the United States.

There are five major laboratories.

Princeton is the largest with something over a quarter of the total national effort. Oak Ridge is next with 18 percent of the total operating budget. It is involved not only in Tokamaks, but in superconducting magnets and is the center of systems studies associated with the next generation of fusion devices. It is the major center of fusion technology at this time. Los Alamos is concentrating on alternate concepts.

I would like to say for Mr. Lujan's benefit that ZT–40 is operational now with a new vacuum vessel and is doing beautifully. In fact, there is an improvement of a factor of 10 over their initial vacuum vessel, and people out there are quite excited, as you may have heard. In that particular concept, Los Alamos has exceeded any previous characteristics worldwide.

The major mirror program activity is at Livermore, which has 15 percent of the total operating budget. The General Atomic Co., an industrial laboratory, is working on the Doublet scheme which is a variation of Tokamaks; it has 7 percent of the budget.

The universities have had a strong participation from the beginning. They not only do a great deal of the fundamental research and bring out many of the new ideas but, obviously, we need a continued input of their highest level of scientists and engineers, and the university program insures that they will take place.

The industrial number of 2 percent is misleading in the sense that that is the direct contract associated with the industrial work—the General Atomic laboratory is industrial—but not included in the 2 percent. We are slowly but surely increasing industrial participation. Something like a third of the total expenditures in the programs are eventually spent with industry and, as you know, the EBT-P is a step toward additional industrial responsibility in which an industrial concern will have total responsibility for an entire project.

There has been continued technical progress this year, not only in the United States, but worldwide. We have had significant improvements in Beta; that is, a measure of the efficiency of the magnetic field in a toroidal device. So much so that the theoretical limitation on Beta is now being reconsidered, and we don't know what that limit is, but it is now quite clear that it is not as low as it was previously thought to be.

There have been advances in purity control and in plasma heating. In the United States, in France, and in the Soviet Union significant advances have been made in RF heating of plasmas. This is radio frequency heating in the same way that a thermionic oven heats food.

There is new data, particularly from devices in West Germany, which point to steady state operation of Tokamaks, something we have looked forward to for a long time.

The Soviets have operated a superconducting Tokamak, T-7, and are quite excited with its results. Spheromak and compact toroid plasmas have been widely produced and stabilized in Los Alamos and Livermore, at the University of Maryland, and Princeton.

In the Linear Systems, mirrors, there were improvements in Beta, in ion temperatures and in end plugging. We have recently raised the power in Elmo Bumpy Torus at Oak Ridge to new higher levels and the scaling has continued to look good. The NBT, that is a similar EBT in Nagoya, Japan—the Nagoya Bumpy Torus—has suggested a new heating experiment, and we are working very closely between Nagoya and Oak Ridge on the Elmo Bumpy Torus concept.

In technology, we have developed and tested 200 kW steady-state 28 GHz tubes and, just last week, reached 225 kW pulsed operation of a 60 GHz gyrotron. This is the highest power, high-frequency, radio-frequency generation ever achieved.

We have tested ordered alloys which have crystal structures specially ordered, under fusion conditions, and the results have been encouraging. Recently a study was completed by Argonne National Laboratory working with McDonnell Douglas and Bechtel—the most mature study yet made of what a fusion power reactor would be like.

In an institutional sense, we established an institute for fusion studies at the University of Texas. This is a powerful intellectual group. They are off to a good start, and we expect very significant contributions from them in the future.

The United States/Japan cooperation is more than a year old and is going very well—their operation of Doublet III—and other participating projects has been helpful to us; and, I believe, they are also satisfied with them. We have selected McDonnell Douglas as the industrial participant in the EBT-P, and that is a new role for industry in fusion. That is moving ahead at Oak Ridge. We established a technical management board involving the best minds we could put together throughout the program to help define the fusion engineering device. All of these matters are underway.

I mentioned the Starfire study. I would like to caution you that this is, by no means, something you would want to sell bonds on yet, but it is encouraging. As I said, it is the first time that a mature economic analysis has been made of what a fusion, power reactor might be, and its power costs fall in the scatter of the projected electric power costs from other devices.

Despite all of these successes, I am sorry to say, that we have had some serious problems as well. The major problems have been delays and cost increases in two of our projects—the TFTR at Princeton and the Large Coil Test Facility at Oak Ridge National Laboratory. Both of these projects have been affected by cost increases due to escalation above that projected, especially in materials purchases. In addition we have had difficulties in the manufacture of advanced components. As a result, we have had to request reprograming of $30 million into TFTR construction in the 1982 budget and an additional $6 million for the Large Coil Test Facility at Oak Ridge.

It is frustrating as a program manager to have to accept these cost overruns. We have tried very hard to establish an intent in the fusion program to meet our budgetary commitments. These overruns are damaging not only to the program, but they affect the laboratories which are involved with them; and, in the end, we have had to absorb them. We have absorbed them almost entirely from other parts of the program. So they have in fact, slowed down the program.

In other instances, however, our efforts have been successful. MFTF-A, the first portion of the MFTF project, is essentially complete and, had it been completed as originally planned, it would have been almost exactly on schedule and cost. The Tritium Systems Test Assembly at Los Alamos is meeting its schedule and cost commitments. The TEXT device at the University of Texas came in almost exactly on its cost estimate. We have bought over $50 million of neutral beams for various devices over the last several years, and they have been almost exactly on their cost projection. So the overruns are not general throughout the program. It is not a problem which we to accept simply because it is there.

A special case of this is the Fusion Materials Irradiation Test Facility at Hanford. When this project was first proposed, we estimated its construction cost at about $75 million. We expected to complete it and be ready for operation in 1982, but we were unable to fund it, on the profile originally intended. The funding profile extended out considerably and, because of the higher escalation rates, that caused its total cost to increase significantly. The total project cost, including necessary R. & D. would today be almost double that originally envisioned.

So despite the need for a facility of this kind, we have concluded that we simply cannot afford to continue at this time; and, therefore, we are requesting its recission. We plan to bring it to an orderly conclusion, complete the design, test the accelerator, which is the crucial R. & D. aspect of the project, and be ready to restart it should an opportunity arise.

Further, because of the need to avoid budget increases in new projects in the next few fiscal years, we have had to halt one other planned project—the ISX-C—the impurity studies experiment-C at Oak Ridge. This project might have made considerable contribution to the program, but it is simply not possible to commence it now in the face of a need for budgetary stability in future years.

ISX-C was to have served the function of providing physics and technology information intermediate between today's Tokamak's pulses of several seconds and the FED, which would be designed to operate with pulses of 100 seconds or more. We are going to have to look to other ways of obtaining that sort of information.

Finally, and for similar reasons as Dr. Pewitt has pointed out, the Department has had to postpone an immediate commitment to an early formation of the Center for Fusion Engineering and to the construction of the fusion engineering device as a means of determining at the earliest practicable date the engineering feasibility of fusion. Our belief in the basic internal logic of the fusion program and the need to take these major programmatic steps is still strong, but proceeding with them now would inevitably result in significant budget increases in future years. The Department presently has this matter under review, as you have previously heard from Dr. Pewitt.

Despite these serious steps, I want to reemphasize that the fusion program remains technically ready to move forward toward a demonstration of engineering feasibility. The fusion data base was examined over a year ago by several independent panels of experts. Each concluded that the data base is adequate to move ahead with a fusion device which would produce significant amounts of fusion energy and would serve as a focus for developing technology. Since those reviews were conducted, more physics information has been obtained and more technology development has occurred, and each of these new developments has been hopeful.

All of this has increased our technical readiness to move forward, and so we have engaged some of the best minds in the program to reexamine the goals of the FED, to optimize its design. That process is not yet complete, but substantial progress has been made in improving the concept, reducing its complexity and size from the older engineering test facility designs, which we discussed with you with in previous years.

With this general introduction, I can now turn to the specifics of the budget and summarize for you very quickly the differences between the earlier and current budgets.

Our budget request for fiscal year 1982 is $65.7 million higher than the fiscal year 1981 budget—a total of $460 million—almost entirely in the operating category, and that is due, again, primarily to the preparation for operation of TFTR, and preparation for cooperation of the TMX upgrade.

The confinement systems program includes both Tokamak and mirrors experimental devices. It receives the major portion of the increase and that provides for the preparation for operation of TFTR and the TMX upgrade.

Development and technology receives a significant increase associated with preparations for the fusion engineering device. That includes the conceptual design activity for the FED. Dr. Pewitt mentioned that it also provides additional funding for such technology subjects as materials development, looking to the FED and power reactors.

Now, I am prepared to answer any questions you have. If you want further detail on the budget breakdown, we have that. It is included in the written record.

[The prepared statement of Dr. Kintner follows:]

STATEMENT OF
EDWIN E. KINTNER
ASSOCIATE DIRECTOR FOR FUSION ENERGY
OFFICE OF ENERGY RESEARCH
U.S. DEPARTMENT OF ENERGY
BEFORE THE
ENERGY RESEARCH AND PRODUCTION SUBCOMMITTEE
OF THE
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

MARCH 18, 1981

## MAGNETIC FUSION PROGRAM

Madame Chairperson and Members of the Subcommittee, a great deal has happened affecting magnetic fusion since I last testified before this Subcommittee, and I am very pleased to be able to bring you up-to-date on these program matters as they affect our FY 1982 budget request.

The objective of the magnetic fusion energy program (Viewgraph 1) in the Department of Energy is to develop the "highest potential of fusion". It is not to take what appears to be the shortest, quickest road to fusion power production, but rather to find the best road, to investigate thoroughly an entirely new field of science and technology so as to provide a base from which sound judgments can be made as to the most economical and practical way to use this ultimate energy resource--the last known physical process by which energy can be produced--the energy of the sun and the stars.

There are a number of important reasons why fusion should be developed as a base energy source. (Viewgraph 2). These include its widely available and easily obtained fuel, significant environmental advantages over combustion of fossil fuels or fission of uranium isotopes, and the potential for a broad range of applications, including process heat and synthetic fuel production.

For this nation the development of fusion offers, in addition, certain ancillary benefits. (Viewgraph 3). Fusion is a high technology field in which the United States exerts recognized world leadership; the strength of the U.S. program is a measure of that continued leadership. A concomitant is that the actions of the U.S. are carefully watched at each decision point. Moreover, fusion inspires development, both within the program itself in terms of the richness of ideas for fusion systems, and in a wide range of other scientific and technological areas in a way no other energy program does. In this way it offers the mechanism for advancing a number of technologies well beyond their present state, and, therefore, provides the opportunity for spinoffs to industrial innovation. These areas include the entire field of plasma physics investigations, the development and application of superconductivity well beyond its present state, the research associated with advanced materials, the development of high frequency, high power vacuum tubes, the design and operation of high voltage, high powered electrical equipment, and the application of new, more powerful computational techniques.

Although less expensive than putting a man on the Moon, magnetic fusion is the longest term, and most expensive in human and material resources, of any development program undertaken for purely civilian reasons. It is, therefore, a test of the ability of society and government to marshall the resources required for a commitment of this magnitude without direct military justification.

In fact, as you have heard in the previous testimony of Dr. Pewitt, the Department is now preparing to address the specific question of fusion's role in the U.S. energy supply program; this question follows directly from the earlier determination of the fusion program's technical readiness to begin its engineering development phase.

Because some members of this Committee are new and not familiar with fusion, I would like to take a few minutes to explain its fundamentals so that you will be able to understand what might otherwise be overly complicated technical descriptions.

In principle, fusion is very simple. Fusion involves the combining of very light nuclei (Viewgraph 4). It is the opposite of fission in that fission involves the splitting of very heavy nuclei. In both instances, mass is lost and converted to energy as described by the equation $E = mc^2$. But to cause this combination to occur, the light isotopes of hydrogen must be raised to extremely high temperature--temperature being a measure of the random velocity with which the nuclei are moving. (Viewgraph 5). When they strike each other at very high velocities--therefore, high temperatures-- they are much more likely to fuse. For a mixture of deuterium and tritium, this temperature is about 60 million degrees, which we have already exceeded in some of our experiments. For deuterium alone, the temperature is about 500 million degrees. This compares with the temperature at the center of the Sun of about 20 million degrees.

At these temperatures atoms have lost their electrons (Viewgraph 6) and become a mixture of ions and electrons known as a plasma, the fourth state of matter. Ninety-eight percent of the mass of the universe is in the plasma state in the stars and interstellar space, but we have known little about plasmas on Earth until recently because temperatures such as these simply do not exist naturally on Earth.

A plasma continues to act as a hot gas (Viewgraph 7) and, therefore, exerts pressure on its boundaries. If we attempt to contain it by material means, it immediately loses its energy to the boundaries and reverts back to a normal gas. We must, therefore, find a way to contain the plasma without depending on material walls. As an aside, let me point out that this fundamental energy loss mechanism is the basis for fusion's inherent safety; given some relaxation by man, the plasma will stop fusing and extinguish itself with some likely local damage to the system.

One practical way to do this is with magnetic fields. Since the electrons and ions in the plasma are charged particles (Viewgraph 8) they tend to be constrained to follow magnetic field lines just as iron filings are constrained in high school physics experiments. Therefore, we can contain plasmas by applying a magnetic field to them. However, if the magnetic field lines are straight, they must be of the order of fifty miles long before sufficiently good confinement for power productions is obtained.

There are two fundamental ways in which this problem can be mitigated; one is simply to squeeze the end of the bundle of magnetic field lines as one would a soft loaf of bread. This creates what is called a linear confinement system or "magnetic mirror". This works, but not well enough; too much plasma still leaks out the ends. So the problem is to plug the ends of the magnetic mirror to the point where net power production is possible. That is the basic research objective of our mirror program, and we are making good progress in doing that.

Another way to reduce end losses is obvious. If we simply bend the magnetic field lines into a toroidal shape, the plasma particles will follow the field lines around the torus instead of being lost. That is the basis for the concept of toroidal magnetic confinement. If we impress a current in the plasma, then the confinement is much improved; that is a "tokamak", the leading magnetic confinement concept worldwide.

In order to make useful amounts of power, we have to reach certain minimum values for confinement of the plasma and for its temperature. (Viewgraph 9). The minimum temperature requirement is about 60 million degrees, and the minimum confinement as measured by the plasma density times the insulation quality of the magnetic field is about $10^{14}$ in the units we usually employ. We have exceeded the temperature requirement, met the density requirement and are within a factor of ten of the confinement measure.

I think it would be useful at this juncture to review a bit of fusion's history (Viewgraph 10). Work first began about 1951--30 years ago--when peaceful controlled thermonclear research began, based on work from the hydrogen bomb. The early researchers were optimistic becaues after development of the hydrogen bomb--which was relatively simple once the atomic bomb was developed--development of controlled fusion was assumed to be easy. That proved not to be the case. From 1959 to 1969, there was a period of disillusionment when the Atomic Energy Commission was very close to canceling all future work on fusion development. But in 1969, as a result of the introduction and startling advances in plasma confinement resulting from the development of the tokamak by the Soviet Union, controlled thermonuclear research received a new lease on life. During the last ten years, research has proceeded to the point that the scientific feasibility of confining plasmas at temperatures and pressures required for production of useful amounts of energy is no longer a serious question. That is a profound achievement—one which now allows us to turn to demonstrating engineering feasibility by applying the scientific knowledge we have gained to a practical result.

The advances which have been made over the last three decades are impressive. As you will see from these next few viewgraphs (Viewgraphs 11, 12 & 13), the increases in plasma temperature, in the confinement capability, and in the length of time the plasma is confined have improved by orders of magnitude and are close to the values required for a power reactor.

As a result of these advances, there has been considerable discussion world-wide as to how to proceed now that the scientific feasibility of fusion can be assumed. During the last year there were four independent reviews (Viewgraph 14) of this questions by: 1) the International Fusion Research Council; 2) the Fusion Advisory Panel to this Subcommittee; 3) the Atomic Industrial Forum, and 4) the Department's Energy Research Advisory Board. This latter was an especially eminent scientific group, perhaps the strongest

On the technology side of the program we also have a primary effort (Viewgraph 17) which is to develop the technology required to support the physics experiments. This includes, for example, systems for heating plasmas. We also have a secondary technology effort, which is to initiate research in areas where advances are needed for power reactors, as for example in large superconducting magnets and in special fusion materials.

An integral part of all our program planning and conduct has to do with its international aspects. (Viewgraph 18). Scientists in fusion worldwide have worked together constructively on the basis that they were helping to decide the future of the race in a field which had no immediate military or proprietary payoff. The U.S. carries out only about one-third of the total world effort in magnetic fusion, but we do provide leadership toward making the world effort synergistic. For these reasons we have, over the last eight years, worked within a number of cooperative international mechanisms to strengthen working relationships with other fusion programs.

The program in the Soviet Union is very strong and has contributed a great deal to the present advanced state of this field. But for obvious reasons, our cooperation with the Soviets has been seriously reduced as a result of recent stiffening of international relationships between the U.S. and the U.S.S.R.

On the other hand, our working relationships with Japan have been strengthened significantly. Japan is spending a great deal for fusion research, and our working cooperations with Japan have increased accordingly.

Both from intellectual and material points of view, the U S. need not foot the entire bill for the development of fusion. That development is something which can and should be shared by all advanced nations.

Now, let me speak for a minute to the institutional structure of the program here in the United States. (Viewgraph 19). There are five major laboratory participants in the magnetic fusion program. The Princeton Plasma Physics Laboratory, with 26 percent of our total operating budget in this fiscal year, is the leading tokamak laboratory; Oak Ridge National Laboratory, which conducts not only tokamak research but works on Elmo Bumpy Torus experimentation, superconducting magnets, materials, and systems studies as well, accounts for 18 percent of the operating budget; Lawrence Livermore National Laboratory is the main center of mirror research and expends 15 percent of the operating budget; General Atomic Company, an industrial laboratory at La Jolla, California, conducts research on a variation of the tokamak called a doublet, and expends 7 percent of the operating budget; Los Alamos National Laboratory is the primary center for work on alternate concepts and also has 7 percent of the operating budget.

There is a very strong university support for the entire fusion program which accounts for 12 percent of our budget and provides not only a considerable amount of technical research supporting the program and new ideas across the board, but develops the input of outstanding professional scientists and engineers that a program of this kind requires.

Although this viewgraph shows industry as only 2 percent of the operating budget, to that must be added the 7 percent at General Atomic, which is an industrial laboratory. Further, a great deal of the effort at the national laboratories is actually subcontracted to industry. As a matter of fact, about one-third of our total budget in FY 1981 of close to $400 million is industry-related. The responsibility of the industrial participants in magnetic fusion has slowly but definitely increased.

This past year has seen continued technical progress in fusion research worldwide. (Viewgraph 20). In toroidal systems we have seen improvements in "Beta"—the measure of magnetic field efficiency in confining plasmas—both here, in Japan, and in the Soviet Union; in fact, the previously assumed theoretical limit to this important value may have been too conservative, and is the subject of intense experimental and theoretical activity at this moment. At Princeton, we were able to raise plasma temperature even further to a point where it is above the minimum required for igniting a plasma and almost the value needed for a power reactor. In Doublet-III at General Atomic, and in T-10 in Moscow, tokamaks were operated with stable plasmas at values of their magnetic safety factor (q) well beyond those required for power reactors.

There were significant advances in plasma heating, especially with radiofrequency power which has many potential advantages over previous plasma heating methods. These advances were made in the United States, in France, and in the U.S.S.R. Further, we were able to investigate a number of questions associated with maintaining plasma purity which imply simpler methods of doing that than were proposed previously.

Furthermore, new data was developed in machines called ASDEX and Wendelstein VII at Garching, Federal Republic of Germany, DITE at Culham in England, and in Japan and the U.S., which indicate that the long held objective of making tokamak type devices steady state rather than pulsed is now clearly in sight. Finally, in the toroidal systems the Soviets operated a superconducting tokamak--T-7--with gratifying success.

In mirror systems, research on the Tandem Mirror Experiment (TMX) at the Lawrence Livermore National Laboratory, which previously proved the tandem mirror concept of "plugging" the ends, was successfully completed. TMX was shut down for modification and upgrade to test improved methods of end plugging which, if successful, would make mirrors a direct competitor to tokamaks as power reactor devices. On the basis of TMX's success, Congress last year approved modifying the Mirror Fusion Test Facility (MFTF-B) for a full-scale test of the tandem mirror principles.

The Elmo Bumpy Torus upgrade (EBT-S) at Oak Ridge National Laboratory continued to improve its performance with significantly increased heating power and frequency. A similar device in Japan--the Nagoya Bumpy Torus--demonstrated successful radiofrequency heating by ion cyclotron techniques. Based on continued EBT technical progress, an industrial contractor (McDonnell Douglas) was selected to commence the design of a successor device, the Elmo Bumpy Torus Proof-of-Principle (EBT-P) experiment.

Progress continued in the technology program as well. Neutral beam sources at 120 kV energy and power of 2 MW have been operated for more than half a second. The length of these pulses is being steadily increased. High power, high frequency microwave tubes for heating plasmas in tokamaks, mirrors and EBT's have been operated at 28 GHz and 200 kW steady-state power levels; and just last week 200 kW pulsed tubes were successfully tested for the first time at 60 GHz, a world's record frequency at these power levels.

Perhaps the most hopeful aspect of our Development and Technology programs was the completion of the so-called STARFIRE studies by Argonne National Laboratory, McDonnell Douglas, and Ralph M. Parsons Corporation. This study was the most mature and detailed projection yet made of what a fusion power reactor would look like. Based on what we know today and what we can reasonably project from our present knowledge, its conclusions (Viewgraph 21), although obviously far from definitive, are that a fusion electric generating plant would be quite competitive with either coal or fission plants.

However, I am sorry to say that we have had serious problems to face as well as considerable successes. The major problem has been that of delays and cost increases in two of our projects, the Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory, and the Large Coil Test Facility (LCTF) at the Oak Ridge National Laboratory. Both of these projects have been affected by cost increases due to escalation above that projected, especially in the procurement of materials such as copper, aluminum and stainless steel, and by difficulties in the manufacture of advanced components. As a result, we have had to request a reprogramming in our FY 1982 budget of 30 million additional dollars into the TFTR construction project, and 6 million dollars into the LCTF construction project.

It is frustrating as a program manager to have to accept these cost overruns. Not only are they damaging to the laboratories involved, but they affect the entire program because our resources are limited and decreasing in "real" dollars. Consequently, we have worked hard to prevent such increases, but in the present inflationary environment and general difficulty of "capping" costs and maintaining schedules, our efforts simply have not been successful in all cases. However, in some instances the efforts have been successful; for example, the Mirror Fusion Test Facility initial phase (MFTF-A) is now essentially complete, and it appears it will meet its Total Estimated Cost (TEC) The TEC is also being held for the Tritium Systems Test Assembly (TSTA) at Los Alamos National Laboratory.

A special case is the Fusion Materials Irradiation Test at Hanford Engineering Development Laboratory in Richland, Washington. When this project was first proposed to the Congress, we estimated its construction cost at about 75 million dollars and expected it to be completed and ready for operation in 1982. As a result of our inability to fund the project as originally intended, and because of escalation beyond what was predicted initially, as well as a new labor contract in the Pacific Northwest which would significantly increase construction costs further, this project now has a total project cost (construction plus associated R&D) that could be almost double that originally envisioned. In recent weeks, we have been able to make a preliminary reconfiguration of the design to stay within the total construction cost. Despite the need for a facility to provide the environment for testing fusion materials at power reactor conditions and these recent design improvements, we have concluded we simply cannot afford to continue this project and are, therefore, requesting its rescission in this budget. We plan to bring the project to an orderly conclusion, complete the conceptual design of a reduced cost facility, and be ready to re-start should the opportunity arise to do so.

Moreover, because of the need to avoid budget increases attendant on new projects in FY 1982 and beyond, we have had to halt one other planned project start-up--the Impurity Studies Experiment-C (ISX-C). This project might have made significant contributions to our program, but it is simply not possible to commence it now in the face of a need to avoid its implications for future year budgets. ISX-C was to have served the function of providing physics and technology information intermediate between today's tokamak experiments which operate at pulse lengths of 1-3 seconds and the next generation of toroidal devices, including the tokamak Fusion Engineering Device (FED), which would be designed to operate for 100 seconds or more. The specific issues relevant to long pulse length are whether we can maintain the position and impurity content of a high beta plasma for reactor relevant time scales. ISX-C was to be designed specifically for this purpose. We are now working to identify more effective means of obtaining the same information on these issues in other ways.

Finally, and for similar reasons, the Department has had to recognize the need to postpone a commitment at this time to an early formation of a Center for Fusion Engineering (CFE), and to the construction of the FED as a means of determining at the earliest practicable date the engineering feasibility of magnetic fusion. Our belief in the basic internal logic of the fusion program and the need to take these major programmatic steps is still strong. But proceeding with them would inevitably result in significant budget increases in future years, and the Department presently has this matter under review, as you have previously heard from Dr. Pewitt, the Acting Director of Energy Research.

In spite of these serious steps, I want to re-emphasize that the magnetic fusion program remains technically ready to move forward with a demonstration of engineering feasibility. The fusion data base was examined over a year ago by several independent panels of experts, as I have previously indicated. Each concluded that the fusion data base was adequate to move ahead with a fusion device which would produce significant amounts of fusion energy and would serve as a focus for developing fusion technology. Since those reviews were conducted, more physics information has been obtained and more technology development has occurred. For example, in the tokamak program, more experimental information and theoretical understanding has been produced on the following topics: operation of tokamaks at higher plasma pressure, radio frequency heating, impurity control with and without magnetic divertors, current drive, and improved fueling. All of this additional information has increased our technical readiness to move forward. Further, we have engaged some of the best minds in the program to re-examine the goals of the FED and to optimize its design. That process is not yet complete, but substantial progress has been made in improving the FED concept, and in reducing its complexity and size from our older Engineering Test Facility designs.

Of course, there is specific physics information and technology development which will be needed for the FED project. Thus, even though there is a technical readiness to begin the engineering development phase, a commitment to new research and development projects to support the FED design and component development would be required if we were to move forward with construction, and implement the engineering mission.

With this general introduction, I can turn to the specifics of the budget. Let me begin by summarizing for you the near-term effects of the differences between the earlier and current FY 1982 budget requests.

## FY 1982 Budget

The Magnetic Fusion Energy budget request for FY 1982 is $460.0 million as shown in Figure 1. This current budget request has increased funding for TFTR, to support a more optimal funding profile for the preparation of TFTR operation; for an enhancement of the technology program in the materials area; and for increased use of the major investments we already have in experimental facilities now operating. The near term effects of reductions in the current budget from the previously proposed budget are associated with three projects discussed earlier--ISX-C, the FMIT facility, and preparation for the CFE/FED. I have discussed the ISX-C problem above. The near term effects of the FMIT termination will be two-fold. First, we are rethinking the materials program's plans to validate fission reactor data under fusion conditions and verify calculations of materials behavior under fusion conditions. Second, we are developing an orderly termination plan and considering the best use within the program of the highly skilled people already assembled and the project equipment already procured. With regard to the CFE/FED project, the current budget will support a continued design effort significantly increased over last year and augmented by a new R&D program directed specifically at the questions most central to the design. Since the Administration at this time has not committed to a strategy for the construction of the CFE/FED, this budget does not provide for a rapid, large buildup of engineering forces to initiate a construction project at the beginning of FY 1983. This budget provides for the maintenance of a strong scientific base program and continued construction activities on the Tokamak Fusion Test Reactor project at the Princeton Plasma Physics Laboratory, the Mirror Fusion Test Reactor-B project at the Lawrence Livermore National Laboratory, and the Elmo Bumpy Torus-P and Large Coil Test Facility projects at the Oak Ridge National Laboratory. The program will also support a limited preconceptual design effort and exploratory studies for the FED. The budget request provides for an increase of $65.7 million for FY 1982 over the FY 1981 level of $394.3 million.

The fusion program is organized into six functional areas. All of these areas, however, are interrelated, and serve to form the basis for a unified and balanced effort in conducting the R&D necessary to develop the highest potential of fusion. The Confinement Systems activity conducts experimental programs aimed at demonstrating and refining methods of heating and containing high temperature plasmas. The Development & Technology activity provides for the development of engineering and technology capability to design, construct and operate increasingly larger and more complex fusion experiments and facilities. The Applied Plasma Physics activity pursues applied experimental and theoretical studies of fusion plasma phenomena needed to predict plasma behavior and perform critical experimental tests and assessments of alternate concepts. The

Center for Magnetic Fusion Energy activity provides for a start on preliminary design for the Fusion Engineering Device (FED) and some initial development support. The Planning and Projects activity is responsible for the conduct of R&D and management oversight in support of construction activities on the next generation of fusion devices. The Program Direction activity provides for the Headquarters personnel requirements associated with planning, budgeting, directing and managing of the overall Fusion program. The FY 1982 budget has been developed to provide the proper balance among these various program activities in this time of fiscal austerity.

The budget will provide increases, as shown in Figure 3, in the Applied Plasma Physics subprogram (+$4.4 million), the Confinement Systems subprogram (+$45.3 million), the Development & Technology subprogram (+$12.3 million), the Center for Magnetic Fusion Energy subprogram (+$5.7 million), and Program Direction subprogram (+$0.6 million). The Planning and Projects subprogram will decrease (-$2.6 million). The focus of these program efforts will be on demonstrating and refining methods of heating and containing high temperature plasmas, developing an engineering and technology capability on individual components, pursuing applied experimental and theoretical studies and continuing a small effort on the assessment of alternate fusion concepts. Funding is provided to complete construction of the TFTR device and prepare for operations. Construction and related developmental activities on MFTF-B and EBT-P will be continued.

## Applied Plasma Physics

Applied Plasma Physics (APP) provides the experimental and theoretical studies of fusion plasma phenomena needed to understand and predict thermonuclear plasma behavior in confinement systems, and pursues the new confinement concepts which may be alternatives to the tokamak and magnetic mirror approaches. In addition, APP supports a large fraction of the fusion research being done at universities; therefore, it provides resources that ensure training of most of the new scientists for the fusion program.

In FY 1982 experimental and theoretical studies will continue to increase the reservoir of knowledge required to support efforts in Confinement Systems and in Development and Technology. Specifically, experimental plasma studies will develop the data base in atomic and molecular physics required for impurity control and will explore promising new methods of diagnostics and plasma heating. Theoretical plasma studies will concentrate on improving the understanding of fundamental properties of fusion plasmas with the central goal of predicting the scaling of important plasma phenomena. The needs of the entire fusion program for computing capabilities will be met by the National Magnetic Fusion Energy Computer Network. In addition to experimental and theoretical studies in plasma physics, research on advanced fusion concepts will be carried out to investigate reactor concepts which have potential advantages over the more conventional tokamak and mirror systems. Figure 4 shows that the FY 1982 budget request for the Applied Plasma Physics subprogram of $76.6

million represents an increase of $4.4 million over the FY 1981 level of $72.2 million. This increase will support R&D efforts in the areas of Advanced Fusion Concepts (+$2.1 million), Fusion Plasma Theory (+$3.0 million), the National MFE Computer Network (+$1.3 million). These increases are partially off-set by a decrease in Experimental Plasma Research (-$1.8 million). Also, capital equipment, which is required to support these efforts, is decreased (-$0.2 million).

The Advanced Fusion Concepts category supports experimental tests of fusion concepts which are alternatives to tokamak and mirrors. This area of research contributes to the major program objective of exploring physics options that might lead to more optimized reactor approaches. The reversed-field-pinch experiment and the compact toroids are being tested with experimental programs of significant size. The torsatron/stellarator approach and the alternate fusion fuel effort are conducted at substantially lower levels. Research to be emphasized in FY 1982 includes extended testing of the reverse field pinch concept at higher temperatures using the ZT-40 device at LANL. Advancement of the compact toroid concept will continue with the fabrication of the Spheromak-1 (S-1) device at PPPL and the experimental comparison of two major approaches to compact toroids using the recently completed test facility at LANL. Studies of confinement approaches that are potentially useful in burning alternate fusion fuels will also be continued.

Experimental studies will continue in FY 1982 in plasma properties to explore and seek to understand the physics of plasma processes relevant to fusion, and to test theoretical models of fusion plasma behavior. Experiments in plasma heating will be conducted to establish the viability, effectiveness, and basis for a variety of radiofrequency heating techniques in fusion devices and for controlling plasma properties such as confinement. In the atomic physics area we will provide atomic data on impurity ions for use in diagnosing fusion devices and in determining the effects of impurities on radiative power losses and particle confinement. An atomic data center will compile new data and disseminate it to fusion scientists. The goal of the diagnostics area is to develop and demonstrate techniques and instrumentation that provide spatial and time resolution for all critical plasma parameters and to standardize instrumentation and methods. Superconducting materials research develops ductile, high magnetic field superconducting magnet materials for fusion machines. The Fusion Plasma Research Facility (FPRF), now being completed at the University of Texas, will provide a medium-scale fusion device (TEXT) to which users and visitors will come to perform plasma experiments and undertake diagnostic development projects.

The FY 1982 budget request will allow this category to maintain heating experiments at lower hybrid (LH) and electron cyclotron resonance (ECR) frequencies, continue mirror and tokamak plasma property experiments, utilize the Texas Experimental Tokamak (TEXT) for development of diagnostic techniques and edge plasma studies, and demonstrate new diagnostic techniques for measuring the current density, neutral hydrogen density, and ion temperatures.

The fusion theory category is responsible for developing analytical and computational models to predict and explain plasma behavior in fusion devices. The predictive capability leads to new ideas for improved fusion concepts, aids in effective allocation of resources among the various confinement schemes based on their reactor potential, and provides guidance for the design and construction of future fusion advices. The interpretive capability is used to support and guide experiments on existing devices. Fusion theory is divided into four topical categories: tokamak, mirror, alternate concept, and generic theory.

The FY 1982 budget in tokamak theory will provide for development of better models for impurity control and divertor behavior, better theoretical understanding of plasma heating and current drive by radiofrequency waves, and studies of disruption control models. The present mirror theory program will be maintained with increased emphasis on simultaneous optimization of the various components of tandem mirrors including the thermal barrier and end-plug designs. Alternate concepts and generic theory programs will be continued at a level of effort with an increase provided specifically for the Institute of Fusion Studies where outstanding scientists have been attracted and research has begun to study confinement in non-axisymmetric systems and on transport in the presence of plasma instabilities.

The MFE computer network provides large and medium scale scientific computation for the entire fusion program. It consists of the MFE computer center at LLNL, user service centers at five locations, mini user service centers at two locations, and remote user service stations at nine locations. The Center currently houses two large scientific computers, one small computer for handling input/output, and an information storage unit. The budget request provides for continued operation of the network in FY 1982 to satisfy the increasing computational requirements of the program.

Confinement Systems

This activity conducts experimental activities aimed at demonstrating and refining methods of heating and containing high-temperature plasmas in tokamak and magnetic mirror systems.

Support of the two primary approaches to magnetic confinement, the tokamak and the magnetic mirror, will be continued in FY 1982. Recent experimental results with tokamak systems have brought the program closer to the achievement of reactor-like conditions, and progress continues in seven critical areas of research: heating, transport and scaling, plasma beta optimization, plasma stability, boundary effects and impurity control, steady-state operation and fueling. Magnetic mirror experimental efforts are also being maintained in the areas of confinement scaling, heating, and improved power balance. The Elmo Bumpy Torus and tandem mirror concepts are being pursued in the magnetic mirror program.

The Confinement Systems subprogram budget request for FY 1982 as indicated in Figure 5 reflects an increase of $45.3 million from an FY 1981 level of $120.4 million to a level of $165.7 million. This level will allow programs to progress in both the tokamak category (+$28.4 million) and the mirror category (+$16.9 million). These significant increases represent principally the transition to the operation of TFTR and TMX-U and the construction of EBT-P. The base confinement systems program remains nearly flat otherwise. The increase for tokamaks consists of $31.2 million for operating and $1.7 million for capital equipment, off-set by a reduction of $4.5 million in the construction program as the ISX-C project is proposed for termination in FY 1981. The operating increase will be used to support the experimental work on current tokamak devices (+$8.4 million) aimed at solving critical problems in the area of transport and scaling, auxiliary heating, beta optimization, impurity control, and fueling and addressing more advanced tokamak issues. Modifications to two major devices will continue (+$1.9 million), to ensure progress toward the goal of self-sustaining ignited plasmas. Preparation for the initiation of operation on the TFTR device (+$20.9 million) will be expanded to ensure that experimental work can start when the facility is complete.

The Tokamak research operations category supports several major experiments including Princeton Large Torus (PLT), Poloidal Divertor Experiment (PDX), Impurity Study Experiment (ISX), Doublet III (D-III), and Alcator C. Each of these tokamak devices is designed for studies of specific technical problem areas, such as high magnetic field confinement, neutral beam and/or radiofrequency wave heating, size scaling, shape optimization and pellet injection fueling.

The FY 1982 request of $60.2 million provides support for the operation of these devices. This will allow the program to continue advanced experiments to investigate steady state operation, RF heating, high beta operation, low q operation and advanced fueling techniques. On PDX, the emphasis will be on the use of poloidial magnetic divertor techniques as a means of active impurity control for high temperature, beam injected plasmas. The Alcator C device will conduct high field, high density experiments to extend the density-confinement time product to reactor levels and for high power RF heating experiments. D-III will continue studies of cross-sectional plasma shapes at reactor-like conditions with higher neutral beam power. ISX-B will be used for assessing high beta plasmas using an upgraded neutral beam heating system, and a new bundle divertor system will be tested for effectiveness as an impurity control system. Funds for enhancing the effort on advanced tokamak concepts are requested in FY 1982. In addition, as completion of the TFTR project nears, it will be necessary to prepare and staff-up for the operation of this major new device. An increase of $20.9 million is requested in order to provide component acceptance tests for training purposes, planning and execution of a variety of pre-operational subsystem tests, development and fabrication of plasma diagnostic systems for TFTR and continued preparation for physics experiments.

An increase of $1.9 million is requested for modification of existing tokamak devices. The divertor on PDX is scheduled to be up-graded to be more reactor relevant along with the addition of ECH heating capacity to PDX at lower power and D-III at higher power and longer pulse length.

In the mirror category, the FY 1982 budget request provides for an increase of $9.5 million in operating, and a $8.6 million increase in construction which is partially off-set by a $1.2 million decrease in capital equipment. The operating request will allow us to pursue the objectives of establishing the scientific and technological data base for tandem mirrors and the elmo bumpy torus concepts, and to develop economically attractive reactors based on those concepts. Experimental devices will continue to be operated to investigate the critical physics issues. These issues include reactor power gain enhancement, confinement scaling, stability limits, and investigation of ways to achieve and improve the efficiency of steady state plasma operation.

The operating budget increase in FY 1982 in the mirror category is primarily associated with the start-up and operating cost associated with the TMX-Upgrade (TMX-U) facility and support of the EBT-P project. The TMX-U project, which is an upgrade of the former TMX device, will be completed in early FY 1982 and will provide a means for testing the thermal barrier concept. In addition, the operation of the Phaedrus device will be supported. This is a smaller tandem mirror device which will be primarily used for testing and developing RF heating. Other small mirror experimental devices receiving support include the Symmetric Tandem Mirror and the Multiple Mirror. The Elmo Bumpy Torus base research program will be continued and the EBT-S device will be improved to include increased microwave and rf power capability and a divertor for improved particle control. The EBT experiment provides important programmatic benefit to the rest of the program through its operation as a steady-state, hot plasma confinement device, and through its role in the development of superconducting toroidial field magnets, and of high frequency, high power microwave sources for radiofrequency heating. The EBT proof-of-principle project will be continued in FY 1982 with a construction request of $14.0 million.

Development & Technology

Figure 6 shows an increase of $12.4 million that is requested for FY 1982 in the Development & Technology subprogram from an FY 1981 level of $74.0 million to a FY 1982 level of $86.4 million. The budget request includes an operating increase of $8.6 million and a capital equipment increase of $4.3 million, partially off-set by a $0.5 million decrease in construction. This is required to provide systems engineering and component development support to current plasma device and future fusion reactors. Six main categories will be supported by the $67.7 million operating request in FY 1982. The Magnetic Systems category funds engineering design and component development support for large superconducting magnets and energy storage systems. The Plasma Engineering category provides for design and component development of plasma heating systems, plasma fueling, direct energy convertors, and vacuum systems. The Fusion Reactor Materials category is directed towards developing the high performance materials required to permit the economic generation of energy from the fusion process. The Fusion Systems Engineering category has primary responsibility for developing the technology for tritium handling, blanket, shielding and other systems for fusion reactors, as well as conceptual reactor design studies, system studies of economics and technical feasibility, plasma system analysis and plant system design and test. The Environment and Safety category will be providing environmental analysis and fusion reactor safety research. The Fusion Energy Applications category examines potential fusion applications other than central station electric power.

The requested increase in the Development and Technology budget request is required to support the program objectives for FY 1982, including operation of developmental 60 GHz, 200 kw gyrotrons; completion of the 20 MJ pulse coil; continuation of LCTF construction and start-up costs associated with this facility; tests of two small 12 Tesla coils with full size superconductors; initial operation of the Tritium Systems Test Assembly facility; obtaining initial thermal/hydrautic results from first wall blanket and shield testing program; achieving first irradiation results from solid breeder development program; completion of high fluence RTNS-II experiments; and completion of the first quantitative assessment of the potential of ferritic steels.

In addition, a request of $6.0 million is included to complete the construction portion of the Large Coil Test Facility. This facility, when completed, will have the capability to test up to six large superconducting magnets in a toroidial array in order to provide a model of the forces expected on magnets in a large tokamak machine. The increase of $4.3 million in capital equipment is also primarily associated with equipping this facility.

## Center for Magnetic Fusion Energy

The budget request for this subprogram for FY 1982 is $9.1 million, as shown in Figure 7. This represents an increase of $5.6 million over the FY 1981 level of $3.5 million. This is a new budget subprogram for FY 1982. A high level scientific review of the program was conducted recently by the Department which concluded that the program was technically ready to enter an aggressive engineering phase. The increase in this category will continue preconceptual design studies, project definition studies, and relevant experiments as a first step toward an aggressive fusion engineering program.

This budget request provides for design and engineering studies at the National Fusion Engineering Design Center on the next generation magnetic fusion facility that will follow TFTR and MFTF. In addition, the budget provides for the conduct of limited scope R&D efforts in support of the design of this next generation device. These efforts will contribute information needed for a commitment to the future establishment of a Center for Fusion Engineering and the construction of a Fusion Engineering Device. Such a commitment will be explored as the Department formulates its FY 1983 budget.

Planning and Projects

The Planning and Projects subprogram provides for the construction, and specific development of major new facilities needed by the other fusion subprogram areas. Construction is under way on both the Tokamak Fusion Test Reactor (TFTR) and the Mirror Fusion Test Facility-B (MFTF-B). Operation of these facilities will play a major role in demonstrating the scientific feasibility of fusion energy. These facilities will be considerably larger than the devices used in previous experiments and will provide a correspondingly greater understanding of magnetically confined plasmas.

Energy at the breakeven level will be produced by the TFTR using a deuterium-tritium plasma, and tandem mirror characteristics will be explored under reactor-grade plasma conditions in the MFTF-B. The FY 1982 budget request for this subprogram is shown in Figure 8 as $118.3 million. This represents a decrease of $2.6 million over the FY 1981 level of $120.9 million.

The TFTR budget request for FY 1982 under this subprogram is $58.7 million. The operating request of $17.0 for R&D in support of the project and for continuation of the tokamak flexibility modification is down from $21.9 million in FY 1981, reflecting the advanced stage of construction activity on this project. The decrease in operating is off-set by increases in capital equipment of $0.6 million and construction of $10.1 million. The construction request of $40.1 million provides for completion of the construction portion of this project at a current total estimated cost of $314.0. As indicated in my memorandum to the Committee of January 30, 1981, I regret that the total estimated cost to complete this project has increased from our previous estimate of $284.0 million to $314.0 and that the scheduled completion had slipped 6 months to December 1982. These actions were required as a result of manufacturing problems and associated delivery delays on this project. While excuses for overruns are never satisfying it is important to recognize that this project represented a very complex, first-of-a-kind device that was constructed during a period of extremely high inflation. My letter detailed the reasons for the need to increase the total estimated cost and we believe we have learned several important lessons that will improve the management of future projects. We are confident that the FY 1982 budget request will allow us to complete the project on schedule and within the total estimated cost.

The other major project provided for under this subprogram is the MFTF-B. The budget request of $50.6 million represents an increase of $21.5 million over the FY 1981 level of $29.1 million. The FY 1982 budget request includes an increase of $5.0 million to $9.1 million in operating primarily for development and fabrication of auxiliary components, and an increase of $16.5 million to $41.5 million for construction activities. This budget request will allow the project to continue on schedule and within costs. The project is currently scheduled to be completed in the fourth quarter of FY 1985 at a total estimated cost of $226.1 million. The MFTF-A project, now included within the rescoped MFTF-B project, is effectively on schedule and within cost with adequate contingency remaining and the project nearly complete (90% costed).

Also included under the Planning and Projects subprogram are funds for general purpose support. This includes $5.7 million to support general plant projects at ORNL and PPPL and $3.3 million to support general purpose equipment requirements.

Program Direction

The request for Program Direction in FY 1982 is for $3.9 million. These funds will provide for salaries, travel, benefits, and other compensation for 77 full-time permanent positions. This manpower provides the technical and management expertise needed to direct and administer the Magnetic Fusion Program.

FY 1981 Budget

I would like to mention briefly the changes to the FY 1981 budget which have been recommended by the new Administration. As I indicated earlier, no funding is included in FY 1982 for two previously planned construction projects, the Fusion Materials Irradiation Test Facility at Richland, and the Impurities Studies Experiment - Phase C at Oak Ridge. A proposed Rescission/Reprogramming request has been submitted to the Congress for FY 1981 which includes a reduction of $14.0 million and $2.0 million in construction funding for the FMIT and ISX-C projects, respectively, based on the decision to terminate efforts on both of these projects.

The other change proposed for FY 1981 is to add $5.0 million in operating to the Confinement Systems subprogram in order to accelerate the preparation for operations activity for the Tokamak Fusion Test Reactor project. This is requested in order to provide a more optimum funding profile for the preparation activities associated with this project, and to provide greater assurances that the project is available and prepared to initiate operation on schedule.

Magnetic Fusion Energy
Program Budget by Subprogram
FY 1982
($BA in Millions)

| | FY 1980 | FY 1981 | FY 1982 | Change |
|---|---|---|---|---|
| Applied Plasma Physics | $ 54.8 | $ 72.2 | $ 76.6 | +$ 4.4 |
| Confinement Systems | 107.9 | 120.4 | 165.7 | + 45.3 |
| Development & Technology | 54.4 | 74.1 | 86.4 | + 12.3 |
| Center for Magnetic Fusion Engineering | 3.3 | 3.4 | 9.1 | + 5.7 |
| Planning & Projects | 127.0 | 120.9 | 118.3 | - 2.6 |
| Program Direction | 2.8 | 3.3 | 3.9 | + 0.6 |
| Total | $ 350.2 | $ 394.3 | $ 460.0 | +$ 65.7 |

Figure 3

### Applied Plasma Physics
### FY 1982 Budget
### ($BA in Millions)

| | FY 1980 | FY 1981 | FY 1982 | Change over FY 1982 |
|---|---|---|---|---|
| **Operating** | | | | |
| Advanced Fusion Concepts | $ 12.3 | $ 16.5 | $ 18.6 | +$ 2.1 |
| Fusion Theory | 15.4 | 19.1 | 22.1 | + 3.0 |
| Experimental Research | 11.7 | 18.8 | 17.0 | - 1.8 |
| National MFE Computer Network | 11.7 | 11.4 | 12.7 | + 1.3 |
| Subtotal Operating | 51.1 | 65.8 | 70.4 | + 4.6 |
| **Capital Equipment** | 3.7 | 6.4 | 6.2 | - 0.2 |
| Total Applied Plasma Physics | $ 54.8 | $ 72.2 | $ 76.6 | +$ 4.4 |

Figure 4

Confinement Systems
FY 1982 Budget
($BA in Millions)

| | FY 1980 | FY 1981 | FY 1982 | Change over FY 1982 |
|---|---|---|---|---|
| **Operating** | | | | |
| Tokamaks (Research Operations) | $ 46.0 | $ 51.8 | $ 60.2 | +$ 8.4 |
| TFTR | 7.5 | 10.7 | 31.6 | + 20.9 |
| Tokamaks (MDF) | 6.5 | 2.9 | 4.8 | + 1.9 |
| Mirrors (Research Operations) | 17.7 | 9.3 | 20.4 | + 11.1 |
| MFTF-B | 0 | 1.0 | 0 | - 1.0 |
| EBT (Base & "P") | 8.5 | 8.1 | 13.8 | + 5.7 |
| Mirrors (MDF) | 0.4 | 9.0 | 2.7 | - 6.3 |
| Subtotal Operating | 86.6 | 92.8 | 133.5 | + 40.7 |
| **Capital Equipment** | | | | |
| Tokamaks | 10.8 | 11.3 | 13.0 | + 1.7 |
| Mirrors | 4.3 | 6.4 | 5.2 | - 1.2 |
| Subtotal Capital Equipment | 15.1 | 17.7 | 18.2 | + 0.5 |
| **Construction** | | | | |
| Doublet III Neutral Beams | 2.5 | 0 | 0 | 0 |
| PDX Neutral Beams | 1.7 | 0 | 0 | 0 |
| ISX-C | 0 | 4.5 | 0 | - 4.5 |
| EBT-P | 2.0 | 5.4 | 14.0 | + 8.6 |
| Subtotal Construction | 6.2 | 9.9 | 14.0 | + 4.1 |
| Total Confinement Systems | $ 107.9 | $ 120.4 | $ 165.7 | +$ 45.3 |

Figure 5

Development & Technology
FY 1982 Budget
($BA in Millions)

| | FY 1980 | FY 1981 | FY 1982 | Change over FY 1982 |
|---|---|---|---|---|
| Operating | | | | |
| Magnetic Systems | $ 12.8 | $ 13.4 | $ 14.2 | +$ 0.8 |
| Plasma Engineering | 12.0 | 19.1 | 17.5 | - 1.6 |
| Fusion Reactor Materials | 10.4 | 12.2 | 19.4 | + 7.2 |
| Fusion Systems Engineering | 8.1 | 10.5 | 12.5 | + 2.0 |
| Environment & Safety | 1.6 | 2.2 | 2.4 | + 0.2 |
| Fusion Energy Applications | 1.8 | 1.7 | 1.7 | 0 |
| Subtotal Operating | 46.7 | 59.1 | 67.7 | + 8.6 |
| Capital Equipment | 5.8 | 8.4 | 12.7 | + 4.3 |
| Construction | | | | |
| Large Coil Test Facility | 2.0 | 6.5 | 6.0 | - 0.5 |
| Total Development & Technology | $ 54.5 | $ 74.0 | $ 86.4 | +$ 12.4 |

Figure 6

Center for Magnetic Fusion Energy
FY 1982 Budget
($BA in Millions)

| | FY 1980 | FY 1981 | FY 1982 | Change over FY 1982 |
|---|---|---|---|---|
| **Operating** | | | | |
| National Fusion Design Center | $ 3.3 | $ 3.5 | $ 5.0 | +$ 1.5 |
| R&D Support | 0 | 0 | 4.1 | + 4.1 |
| Total Center for Magnetic Fusion Energy | $ 3.3 | $ 3.5 | $ 9.1 | +$ 5.6 |

Figure 7

### Planning & Projects
### FY 1982 Budget
### ($BA in Millions)

| | FY 1980 | FY 1981 | FY 1982 | Change over FY 1982 |
|---|---|---|---|---|
| **Operating** | | | | |
| TFTR | $ 23.4 | $ 21.9 | $ 17.0 | -$ 4.9 |
| MFTF-B | 11.7 | 4.1 | 9.1 | + 5.0 |
| FMIT | 10.5 | 8.5 | 0 | - 8.5 |
| Other | - 1.0 | 0 | 0 | 0 |
| Subtotal Operating | 44.6 | 34.5 | 26.1 | - 8.4 |
| **Capital Equipment** | | | | |
| TFTR | 1.6 | 1.0 | 1.6 | + 0.6 |
| FMIT | 0.6 | 0.4 | 0 | - 0.4 |
| General Purpose Equipment | 3.0 | 3.0 | 3.3 | + 0.3 |
| Subtotal Operating | 5.2 | 4.4 | 4.9 | + 0.5 |
| **Construction** | | | | |
| TFTR | 35.0 | 30.0 | 40.1 | + 10.1 |
| MFTF-B | 28.2 | 25.0 | 41.5 | + 16.5 |
| FMIT | 10.0 | 22.6 | 0 | - 22.6 |
| General Purpose Equipment | 4.0 | 4.4 | 5.7 | + 1.3 |
| Subtotal Construction | 77.2 | 82.0 | 87.3 | + 5.3 |
| Total Planning & Projects | $ 127.0 | $ 120.9 | $ 118.3 | -$ 2.6 |

Figure 8

**Mrs. Bouquard.** Thank you very much, Dr. Kintner. We are certainly very grateful for your testimony, as well as your testimony, Dr. Pewitt.

You are an excellent educator on the fusion energy program. I believe that you were my first instructor, and I shall always be grateful for your expertise.

**Dr. Kintner.** Thank you very much.

**Mrs. Bouquard.** Before I came over to the hearings, I was looking at our plans for our fusion engineering program. I think there are some near-term requirements that will have to be made in our fusion program. I was wondering—a report is due to Congress in July of this year for the plans for the creation of a National Magnetic Fusion Engineering Center. What studies are being undertaken by the Department of Energy to discern if the Center for Fusion Engineering is a useful concept for focusing industrial and laboratory involvement in fusion and engineering that would be involved in this report?

**Dr. Pewitt.** Initially we moved quickly in trying to figure out not whether but how to establish a center for fusion engineering. I was devoting, personally, a great deal of my time to that effort. Other events interfered and we got involved with different things. I intend to get that effort cranked up in the near future, if it is deemed appropriate. That decision on whether we are going to have a plan for how to establish such a center has not yet been made; but, after we have gotten through this initial phase of testimony, that is going to again take a fairly large portion of my time.

**Mrs. Bouquard.** After we get through the budget hearings, then you are going to become involved with the studies?

**Dr. Pewitt.** I am presently involved. The former Director of Energy Research set up an executive group to look at the establishment of the Center for Fusion Engineering. He was a part of that group; Ed Kintner was part of that group; I was part and Ron Young, another Associate Director, was part of that group. I had a working group and we were examining not whether, but how to establish that center.

**Mrs. Bouquard.** Are you focusing on the industrial and laboratory problem, process?

**Dr. Pewitt.** I think the Center for Fusion Engineering should be called the Industrial Center for Fusion Engineering. We certainly are looking at how one can bring the best industrial management experience in this country to bear on the problem of establishing the Center for Fusion Engineering, which we view to be a management device for an engineering program and not just the Center for Fusion Engineering to build an FED. We consider who builds the FED to be a separate issue, but this is the management expertise, and I think it requires the best the country has.

Now trying to get the best and still satisfy all of our requirements within the constraints of Government procurement is a real art and that is what we were looking at before other events intervened. I am still personally committed to that effort.

**Mrs. Bouquard.** My interest is that we comply with the act, Dr. Pewitt.

**Dr. Pewitt.** Yes, ma'am.

Mrs. Bouquard. We have strained budgetary pressures that we are all very much aware of, but I think that we should compare the expenditures of money and manpower between our efforts and the European efforts and the Soviets and the Japanese programs where they also had extreme inflationary pressures, as well. Are you taking this into consideration as you look at the cutbacks in our program?

Dr. Pewitt. I said a few days ago that if I felt that we were posturing this program so that the U.S. program in fusion was going to be in a position to look at the tailgates of somebody else's program in fusion, I wouldn't be the administration witness, and I mean that. I recognize budget constraints, as anybody in the Department does right now. At the same time, I don't think we can do anything that is threatening to something as important to the industrial capability of this country over the next many decades as is magnetic fusion.

Mrs. Bouquard. I notice that, because of the advancements in fusion technology in recent years, the JET project, the Joint European Torus, managing council is preparing to ask the East to accelerate the pace of funding for this Torus. Because of the progress we have made, they are going to freeze their funding.

Dr. Kintner. We have a viewgraph. Which shows a recent view of the JET project construction. The large building in the foreground is the main laboratory building at the Culham Laboratory, Great Britain, and the construction behind it is the JET building.

Another viewgraph, is the comparison of the costs of JET, JT-60 and TFTR. Despite our problems on TFTR, in comparison to the others, we are still doing reasonably well from a total cost point of view.

The original JET estimate was 258 million units of account. They recently revised that upward to 369 million and added 116 million units of account to the performance of JET. They are accelerating two major aspects of the project—the neutral-beam heating power and the radioactive maintenance and other capabilities for R-T operations. They originally intended to start with hydrogen operation and later add the deuterium and tritium capability. So that, I believe, is the acceleration you are talking to.

Mrs. Bouquard. They are accelerating their program on the basis of the advancement, the technology, with our program; is that correct?

Dr. Kintner. That is one of the reasons for it. I think if we had not already made these moves in TFTR, they would not be doing it yet. They have, picked up on that initiative on our part, they are increasing the capability of JET and bringing it to a full capability at an earlier time, I think they are going to be a year or two earlier than they had previously planned. TFTR is still, however, about a year ahead of JET.

Mrs. Bouquard. I would like to recognize our ranking Republican member. Mr. Lujan, do you have any comments at this time?

Mr. Lujan. Thank you, Madam Chairman.

Mrs. Bouquard. I think according to the rules of the committee, we will recognize Mr. Forsythe for questions after remarks that you have, Mr. Lujan.

[Pause.]

Mrs. **Bouquard**. Without objection, go ahead.

[Multiple voices.]

Mr. **Goldwater**. It looks like I am the only one prepared, so I will go ahead. [Laughter.]

Mrs. **Bouquard**. Without objection. Mr. Goldwater?

Mr. **Goldwater**. Dr. Kintner, on page 12, you talk about certain cost overruns on the Tokamak reactor and the large coil test facility. You put some figures up just a few minutes ago, what was the additional estimate on both of those and what is your latest estimate, and what assurances do we have that we are going to stay on target?

Dr. **Kintner**. The original estimate in 1976 for TFTR was $215 million. The present estimate is $314 million. The major single increment of that $100 million increase is shown in this next viewgraph. We have made a careful analysis of the actual escalation during any given year versus the expected when the project was originally proposed. The actual escalation has been about $94 million. We anticipated about $40 million and the remaining $54 million, therefore is really unanticipated escalation.

The other increases are of two specific kinds. One is the buildings themselves, which cost more than we expected them to. The other increase is in the manufacture of components which are not really developmental. They are not run-of-the-mill components for industry, but they are nevertheless not state of the art. Those have cost more than we expected them to in almost every instance—the vacuum vessel, the toroidal field coils, the neutral beam power supplies, and the neutral beams themselves. These then have added up to the total of about $100 million, which is the increase over the original cost estimate.

Mr. **Goldwater**. What about the facility at Oak Ridge—the large coil?

Dr. **Kintner**. The large coil project—the original cost of the large coil project was $16.95 million, and the present estimate is $38 million. In that case, there is also increased escalation. Because of the escalation rates, then these costs have gone up; but, in the case of the large coil project there were other factors. We had an international agreement for testing of superconducting magnets and, in order to adequately test those coils we had to make changes in the LCP facility, and that has added additional costs as well.

In addition to that, there were something of the order of $2 million which was just unanticipated extra cost.

Mr. **Goldwater**. What assurance do we have that these are accurate figures that we are not going to keep going through this kind of situation?

Dr. **Kintner**. I wish I could say you have absolute assurance, Mr. Goldwater, because, as I said earlier in the testimony, this is not a pleasant thing to come to the committee and to the Congress year after year and ask for more money.

The problem is that, in this kind of an inflationary period and in research and development activities of this kind, to some degree, we are in the position of "pushing on a rope."

In some cases, we are successful, as we were in MFTF-A and in the TSTA at Los Alamos and a number of other small projects in the program, of meeting our cost and schedule projections. But, in these two cases, the TFTR and LCP we simply were not able to do that. We have strengthened the project management. As a matter of fact, a project manager has been appointed at the large coil project at Oak Ridge. We have brought in additional project management strength at Princeton. But and I think there is one other factor which we are going to have to consider in the future and that is that, with the kind of inflationary circumstances in which these projects are being carried out, we have got to put in more margin from the beginning so as to avoid these kinds of overruns of the total estimated cost. I dislike doing that because it tends to provide a bigger pasture in which the project can graze; and, in the end, I am not sure that that is the best use of resources, but it is not something which we can continue to do; that is, initiate projects on one basis and go back and ask for additional funds in future years. So we are going to have to recognize that we are going to need more contingency in the original cost estimates.

Dr. PEWITT. I would just like to elaborate on that. There are a couple of approaches to the management of large government projects. One is to make a tight estimate and try holding people's feet to the fire to get the projects done at minimum cost.

If we were only being held accountable for total program funding, that is how we would manage the projects. However, we have found that that, generally, has not been acceptable. If you overrun a project that is tightly estimated and due to circumstances—unanticipated things coming up—you just can't make those costs, then you are accused of being a bad manager.

Mrs. BOUQUARD. Will the gentleman yield at that point?

Dr. PEWITT. Yes.

Mrs. BOUQUARD. Didn't the government take $30 million out of the TFTR program in 1978? Didn't this have some bearing on this?

Dr. PEWITT. And at that point, the officials in charge of the program, not at the program level, but more at the level of my responsibility right now, should have at that point insisted that the TEC be revised to reflect that, but the TEC was not revised. I have testified already before this Congress. We have had to slip some projects, and we are going to be coming back with revised TEC's. You cannot reschedule the obligations to a project and expect that that does not impact the total cost. It is ridiculous. I just cannot do it in good conscience. We are going to go back on some projects that we are having to slip, and we are going to tell you that TEC went up because of that slip. We are not being honest with you, if we don't.

Mr. GOLDWATER. How about the cost in changes in the scope of the program? That has got to add new dollars to it?

Dr. KINTNER. To which project are you referring, sir?

Mr. GOLDWATER. Well, either one of them—the changes in requirements or changes in——

Dr. KINTNER. Well, in the case of the Tokamak Fusion Test Reactor, that has been a separate category called the Tokamak Facility Modification. That is separately accounted for and is supported from operating funds. As far as the project itself is concerned, the base TFTR, that has not changed in scope from its beginning.

In the case of the Large Coil project, we did, as I said previously, increase some of the characteristics as, for example, the total cooling capacity and there were several other minor modifications that added several million dollars to the project.

The major factor was one of escalation. For example, aluminum prices, which were a large part of the project went up 35 or 50 percent. Stainless steel went up much more than just the recognized inflation rates.

I am not trying to apologize, you understand, or alibi. I really think it is unfortunate but that is the environment we are in.

Mr. **Goldwater**. I would not think that any apologies are necessary. The main thing is we understand why this is happening, and the Congress and the administration are to decide what we are going to do about it. What becomes disturbing is when you say these things are kind of hidden from view with no logical explanation for them.

Dr. **Kintner**. Yes, sir.

Mr. **Goldwater**. Thank you, Madam Chairman. I thank my colleagues for yielding their time.

Mrs. **Bouquard**. For the benefit of those who do not understand our procedures of the subcommittee, we recognize our members in order of their appearance.

At this time, I would like to recognize, Mr. Forsythe.

Mr. **Forsythe**. Thank you, Madam Chairman.

I would like to go back again on this cost problem and that viewgraph that showed the 7-percent escalation factor in the original number, which obviously, in the world we have been in, is fairly ridiculous and so that the actual numbers do still look fairly reasonable. If you look at the equation, the CPI index that we have been looking into, as I think you said, also, Dr. Pewitt, this problem that, if you stretch out, then you always hit the high dollars down the road. Is that correct?

Dr. **Pewitt**. That is correct. You have to realize though the inflation numbers we are allowed to use are dictated to us. They are not our estimates, sir.

Mr. **Forsythe**. Yes.

If, as you indicate, you really feel that this has got to get up front as we move down the road with these things so that nobody has been blindsided, which I think has happened in the past and, certainly, I think as far as I am concerned and this committee, that it is very very important because it is far easier to be able to try and work with the real world, instead of finding out we were not in the real world.

Thank you.

Mrs. **Bouquard**. Thank you, Mr. Forsythe.

Mr. Lujan?

Mr. **Lujan**. Thank you very much, Madam Chairman.

I don't want to plow old ground, but it still concerns me that you are all pushing for a lower figure than OMB. As I said at the very last hearing, it has been my experience that OMB usually wins out. I wish them luck. [Laughter.]

The extra $15 million could very well have served us for not maybe all programs but could have certainly prevented zeroing the Impurity Studies Experiments and FMIT. The committee put back

$10 million for FMIT into their budget. What is your reaction going to be to that? Have we wounded you terribly by putting in an additional $10 million.

Dr. PEWITT. You are not talking to me. You are talking to the administration's witness. [Laughter.]

So I will give you the administration witness' answer, which is that the budget proposed to you represents the judgment of the system on the precisely correct number; it would not be proper for me to support either additions or deletions from that budget.

If you were talking about additions to the program, and I weren't constrained by a dollar figure, I think there are probably some other things in the program that might come before such an addition for FMIT, sir.

Mr. LUJAN. Let me just ask about the rationale of those two particular programs—the Impurity Studies Experiments—have you found out all we need to know about the impurities in the plasma—how we would take care of it?

Dr. PEWITT. Absolutely not, not on the impurities. With the Impurity Studies Experiment, the information—that was the objective of that project—was important information. We are going to have to figure out alternative ways under the administration's budget in order to derive that information, and we are looking, as good soldiers, for ways to do that.

Mr. LUJAN. FMIT—the reason was to stretch it out to later on? I am trying to find out the rationale for——

Dr. PEWITT. I will let Ed talk to that. He can talk to that in more detail. Basically, it did not appear to be an affordable project in the program now. That means that, under the funding profiles, we have to be realistic—and that is not a flat-out year funding profile, either. We do need to look at alternatives, and I think we can. You have a gentleman who at Los Alamos has been helping design that accelerator, and we are going to make sure that effort is not wasted. We are going to come back and relook at it when we can figure out how to do it at a cost affordable within the program. We have to have that information sooner or later. You cannot build an engineering device without materials information subject to those 14 MeV neutrons and we will be coming back to that—no question—but right now we can't afford that project in the program.

Mr. LUJAN. What happens then to work that has been done on accelerators?

Dr. PEWITT. We will finish it up, and it will be information we use when we come back to address that objective of the program.

Dr. KINTNER. Not only that, Mr. Lujan, as we said last year, that accelerator at Los Alamos has really——

Dr. PEWITT. First class.

Dr. KINTNER [continuing]. Pioneered a new field of accelerators, and it is going to be useful not just to materials testing, but to medical research and others. So we feel that the prototype should be completed and tested.

Mr. LUJAN. I don't mean to be totally provincial about it. I was going to ask about the ZT-40. You have indicated that it's going well?

Dr. KINTNER. Yes.

Mr. **Lujan**. In visiting over there, everybody always points out what more we need—new power source, new flywheel for the ZT-40. Maybe you shouldn't let us go out to the laboratories and then we can come back and say—hey, about the money for the flywheel and the new power source—how about it? [Laughter.]

Dr. **Kintner**. Well, we have supplied the additional funding that provided the modifications—ZT-40 resulted in these improved results that I just mentioned to you. As you may know, Los Alamos is working with Culham, in Great Britain, and Padua, in Italy, on the design of the next device in reverse-field pinch development. That device would be built at Culham, but it would have very close involvement of people from Los Alamos.

Mr. **Lujan**. Are you saying they don't need——

Dr. **Kintner**. I don't know about the flywheel because they haven't told us they needed flywheels; but, as far as what we know and as far as the ZT-40 is concerned, we are providing what is required to fully exploit it.

Is Jim Decker here? Is that right?

Mr. **Decker**. That is right.

Mr. **Lujan**. Thank you, Madam Chairman.

Mrs. **Bouquard**. Mr. Young?

Mr. **Young**. I do not have any questions. Thank you.

Mrs. **Bouquard**. Mr. Hollenbeck.

Mr. **Hollenbeck**. I have no questions.

Mr. **Lujan**. May I ask another one, Madam Chairman?

Mrs. **Bouquard**. Mr. Lujan, please proceed.

Mr. **Lujan**. Dr. Kintner, the statement that you made in your presentation, basically, that we are into an engineering phase in fusion, is that a strong statement?

Dr. **Kintner**. No. What we said was, in the viewgraph on history, that we had established the scientific feasibility of fusion and the objective for the next decade to be to establish the engineering feasibility.

What we have said and what has been accepted by the Buchsbaum Committee and others is that there is still a great deal of science to be done, and the present program, with regard to physics development, should continue, but it should not grow rapidly.

Mr. **Lujan**. But you can foresee by projections of some kind that the time life, or whatever you call it, will move on without all of the different——

Dr. **Kintner**. Right. And while we continue this rich and highly productive physics experimental program, we now feel confident enough that we can move into the technology development area, and that would be incremental to the physics. That is the basic strategy of the program.

Mr. **Lujan**. Thank you, Madam Chairman.

Mrs. **Bouquard**. From the work that has been done so far in the FMIT program, can you tell us, on a positive note, what some of the potential spinoffs there have been from this program to the DOE or to our national defense program?

Dr. **Kintner**. Do you mean for the fusion program as a whole?

Mrs. **Bouquard**. For the fusion program—the spinoffs related to the DOE or to the defense program?

Dr. KINTNER. One of the first and most immediate has been the device that is used to cure the paint on Coors beer cans, so I am told.

Mrs. BOUQUARD. Maybe, we should have rescissions. [Laughter.]

Dr. KINTNER. The first application was to curing the paint on beer cans. I don't know whether that is apocryptial or not, but that is my understanding. That happened several years ago.

Since that time, we have continued to develop a number of areas in which you might not consider them as commercial spinoffs right now, but they inevitably will become that. One of the most important is superconductive magnets—we are doing far more in terms of the development and application and testing of superconductive magnets than any other field. That is the Large Coil project at Oak Ridge, but it is just the beginning of the usefulness of the development of technology for superconductivity.

Another is the development of particle beams and neutral beams at Oak Ridge and at Berkeley and Livermore. That is well in advance of anything previously done in the field.

The FMIT accelerator I mentioned has spinoffs in a wide-range of applications, including medical.

The high-power, high-voltage switching and control equipment we are using for heater power supplies is well in advance of anything developed previously in electrical engineering. Materials developments for fusion will, inevitably, have applications outside fusion. The computational techniques we have developed for plasma theory and the use of computers and codes in the National Magnetic Fusion Computer Center is applicable much more broadly than fusion.

These are just a few of the places where, in a very broad sense, and across the whole field of technology, fusion is working on the frontiers of science and application. The spinoffs have not been large in terms of commercial application and profit yet, but I think it is inevitable that, such a field—in such a broad field—and moving as far as we are moving, is going to inspire industrial and academic advances.

Mrs. BOUQUARD. You mentioned the $6 million cost overrun on the large coil project at Oak Ridge. Who is participating in this program?

Dr. KINTNER. The facility itself is at Oak Ridge. There are six coils to be tested there—three of them from the United States—General Electric, Westinghouse, and General Dynamics. There is one from Switzerland, one from West Germany, and one from Japan. These will all be tested as a toroid at Oak Ridge.

All of the technology associated with the manufacture and design of these foreign magnets will be available to us as a result.

Mrs. BOUQUARD. Who is going to deliver their large coil first?

Dr. KINTNER. I think the General Electric coil is ahead of all others at the moment. There are three General Electrical officials in the room here. [Laughter.]

Mrs. BOUQUARD. Does the technical community believe there will be a significant reduction in the risk associated with building the FED by continuing in the basic research mode for another 3 or 4 years instead of focusing the fusion program on an engineering device?

Dr. **Kintner**. There would be a reduction in risk with each year because, clearly, the data base and assurance with which any one of the technical decisions on a project of this kind is made is improved with additional experimental results. But we believe that the base is there to proceed. Those four committees, which I mentioned in my testimony, have all reached the same conclusion that we can proceed today on these projects. You need to recognize, of course, that a project of this kind has a life of about 10 years, and that during the first 4 or 5 years, it is still susceptible to the input of major new technical information, so we will be able to confirm our decisions, avoid errors, make improvements in the project for another 5 years, if we start today.

Mrs. **Bouquard**. Have you prepared the risk reductions versus the cost increase factor, though?

Dr. **Kintner**. Once again especially when we are dealing with 10-percent or 15-percent escalation factors.

Mrs. **Bouquard**. What is going to be the impact on the program if we continue for 4 years, with just cost of living increases? What are the implications of this, Dr. Pewitt?

Dr. **Pewitt**. The original start of construction would not have been until 1984. There was never any intention in the schedule to start construction before 1984. One would have been doing scoping designs and preparing. We are still proposing to continue that activity. That is the reason why I said in my testimony that the program we are proposing to you this year is not inconsistent. We are still achieving that objective. The 1983 and 1984 budget decisions are key to the achievement of the 1990 date for initial operation of the FED. We would not start pouring concrete until late 1984 under plans in any case.

Mrs. **Bouquard**. Will the FED test materials then?

Dr. **Pewitt**. No, we are going to have to look at other affordable ways of testing materials, and we will be doing that.

Mrs. **Bouquard**. Do you think that our Center for Fusion Engineering will be established within the present 1981 and near-present 1982 budget constraints?

Dr. **Pewitt**. Budget constraint is not the problem on establishing CFE. There are lots of options for establishing CFE. We never envisioned that CFE would be a major budget item initially. One looks at it as a management concept to be a focus of the engineering effort now. How fast one builds that concept up and whether and how fast one builds it up in that CFE was never really decided. CFE could be designated today if it made sense and we could get through all of the procurement business. It doesn't take dollars to designate it.

Mrs. **Bouquard**. Does Secretary Edwards believe that our program is technically ready to move forward—the magnetic fusion program?

Dr. **Pewitt**. I told him that it is ready to move into an engineering phase. Unless somebody has told him differently, that is what he believes.

Mrs. **Bouquard**. We certainly hope that no one has gotten to him since you talked with him, Dr. Pewitt. [Laughter.]

Dr. **Pewitt**. I left him with a 3-by-5 card, ma'am.

**Mrs. Bouquard.** I think maybe we should send Ed Kintner to him to further explain the value of our program.

**Dr. Pewitt.** We are trying to arrange that.

**Mrs. Bouquard.** I have no further questions. You certainly provided very valuable testimony for which we are certainly most appreciative.

Does Staff have any questions they would like to ask at this time?

**Dr. Mense.** Yes, I have a few questions.

**Mrs. Bouquard.** Without objection. We will hear from Dr. Mense.

**Dr. Mense.** Thank you.

Let me ask a few quick questions here, particularly, with regard to the international involvement of the fusion program.

First of all, is it safe to say that Japanese are spending more money than the United States per capita on their fusion program?

**Dr. Kintner.** Yes, sir.

**Dr. Mense.** Is it safe to say that a larger percentage of the Japanese Government money involved in fusion research is within Japanese industry?

**Dr. Pewitt.** May I expand on that.

**Dr. Mense.** Yes, you may.

**Dr. Pewitt.** It scares me. They seem to be able to mobilize their industry, academia, and Government involvement. Our inability to do that in this country, ought to scare everybody concerned about the economic future of this country. But we cannot involve all sectors of the economy the same way the Japanese do. I mean they use direct subsidy to build the capability so they can go into energy markets. It is just terrible what we have to do. We would like to do more, but you won't let us.

**Dr. Mense.** That can be changed. [Laughter.]

Again, in pursuing other countries' involvements, is it, in fact, fair to state that the Japanese have a larger percentage of their fusion budget with the Japanese industry?

**Dr. Kintner.** I believe that is correct. They have a very strange budget system—one in which personnel costs are not included in the program budgets and so, in the universities, in the laboratories and so forth, whatever costs are associated with personnel are never accounted for as part of the program; and, therefore, the program budgets simply reflect material expenditures—hardware, projects, and so forth. But, generally speaking, that is the case and, in the case, for example, of JT-60, that is a totally Government project.

**Dr. Mense.** Is it fair to state that, once the Japanese have established scientific credibility in their fusion program, the technology transferred to industry will be automatic?

**Dr. Kintner.** I suppose "automatic" is as good a word as could be chosen. The work is being done there. Maybe it isn't even a transfer any more.

**Dr. Mense.** Dr. Pewitt, do you want to expand on that.

**Dr. Pewitt.** I just want to say not "will be automatic;" it will have already occurred.

**Dr. Mense.** So, therefore, it seems appropriate that, what we should do is to start moving with an emphasis toward industrial involvement in the U.S. magnetic fusion programs; is that not correct?

Dr. KINTNER. That is correct, Al; but, as you know, that is what we have been doing slowly and steadily. We have tried to avoid a circumstance like the one that occurred in the fission reactor business in which too many industries got involved too early. Many people got hurt. We don't want to do that. This is a long-term proposition, but we have been increasing the industrial participation not only in quality, but in kind. That is, I hope, going to continue. It was reflected in the recommendations associated with CFE and the FED, and Dr. Pewitt's comment about how a CFE would be organized.

Dr. MENSE. One of the major initiatives to provide some measure of assurance of industrial involvement in the fusion program is the Center for Fusion Engineering as was envisioned by the previous Congress and the past administration. Is it the new administration's policy that the Center for Fusion Engineering will not be something that will be pursued either in the fiscal year 1981 or 1982 budget?

Dr. PEWITT. I have never said that. At a point in time I could not testify that we intended to implement the act. I have not asked the question on when we can go forward with designating the Center for Fusion Engineering. I will ask that question at the right time to make sure we get the right answer.

Dr. MENSE. Then it is your belief that there is possibly a right time during fiscal year 1981 and/or fiscal year 1982 to ask that question? You were not precluding moving forward with the Center?

Dr. PEWITT. I do not want to take any actions that would preclude us from moving forward at the earliest possible date. No, sir, I do not.

Dr. MENSE. So there is nothing in the fiscal year 1981 or 1982 budget which would preclude you from doing that?

Dr. PEWITT. That is correct.

Dr. MENSE. Thank you.

Mrs. BOUQUARD. Thank you very much, Dr. Mense.

Dr. KINTNER. Could I just make a comment, Mrs. Bouquard.

Mrs. BOUQUARD. Please proceed, Dr. Kintner.

Dr. KINTNER. We were talking about the Japanese. Something I thought was appropriate was John Kenneth Galbraith's article in the Washington Post several weeks ago in which he said, "The fault dear Brutus is not in our stars, but in the Japanese." [Laughter.]

Mrs. BOUQUARD. We certainly appreciate your participation. If there are no further comments or questions, we will dismiss these hearings and resume our hearings on the Department's budget tomorrow afternoon, at 2 p.m., in the same room. The subjects for tomorrow's hearings will be the DOE's programs for nuclear waste management, conventional reactor systems, and advanced isotope separation technology.

If there is nothing further, then this subcommittee stands adjourned.

[Whereupon, at 3:30 p.m., the subcommittee adjourned to reconvene at 2 p.m., on March 19, 1981.]

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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### THURSDAY, MARCH 19, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met at 2 p.m., in room 2247, Rayburn House Office Building, Hon. Marilyn Lloyd Bouquard (chairman of the subcommittee) presiding.

Present: Representatives Bouquard, Ottinger, Lundine, Lujan, Forsythe, and Hollenbeck.

Mrs. Bouquard. Our hearing will come to order.

I want to welcome everyone to our hearings this afternoon.

Today we are receiving testimony in three very important areas of our nuclear program: nuclear waste management, conventional reactor systems, and advanced isotope separation. These activities contribute significantly to the advancement of nuclear technology and to the resolution of certain issues which impact the nuclear industry.

Nuclear waste management is an area that has long needed a solution that is safe and permanent. This subcommittee has actively supported the Department in its effort to provide that solution.

Today, I understand the Department will describe, as part of its testimony on waste management, a revised program which is responsive to the subcommittee's desire that we get on with demonstrating that the technology does exist for the permanent isolation of nuclear waste.

In regard to conventional reactor systems, we recognize that a number of important elements of the nuclear program are grouped in this area, including high temperature reactors, light water reactor R. & D., and Three Mile Island. We will be anxious to receive your testimony on these activities.

Finally, the DOE program on advanced isotope separation will be covered today. Again, this is an important area of the overall program because of its potential to substantially reduce the cost of uranium enrichment.

Gentlemen, we certainly have a full and interesting afternoon. And I suggest we proceed.

The first item today is nuclear waste management. And because of Congressman Lundine's keen interest in the subject, I have asked him to chair this portion of the hearing.

Mr. Lundine, if you will now chair this portion of our hearing, thank you.

Mr. LUNDINE [presiding]. Thank you very much, Madam Chairman.

And I have some remarks for which I request unanimous consent for inclusion in their entirety in the record. I would rather listen today than speak. I will not read these remarks.

Mr. LUNDINE. I would like, first of all, want to welcome Mr. Gates. This is the first opportunity I've had to exchange ideas with you and, second, note that this is an area of great interest to me and I think one of the great challenges facing our society to develop an adequate approach to nuclear waste management.

During the question period we will have an opportunity to get into a discussion of some of those issues. So I won't try to introduce them now.

Mr. Forsythe, do you have anything you would like to say?

Mr. FORSYTHE. No, thank you, Mr. Chairman.

Mr. LUNDINE. Mr. Gates.

## STATEMENT OF MAHLON GATES, ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY SHELDON MEYERS, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR WASTE MANAGEMENT; AND DR. THOMAS DILLON, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR REACTOR PROGRAMS

Mr. GATES. Thank you, Mr. Chairman.

Mr. Chairman and members of the subcommittee, it's a pleasure to again appear before this subcommittee in order to cover activities related to nuclear waste and, subsequently, to conventional reactors systems and advanced isotope separation.

I am joined today by two colleagues: on my left, Mr. Sheldon Meyers, Deputy Assistant Secretary for Nuclear Waste Management; and on my right, Dr. Tom Dillon, Deputy Assistant Secretary for Nuclear Reactor Programs.

Mr. Meyers will lead off the testimony, sir, on nuclear waste management.

Mr. LUNDINE. Thank you.

He is not a stranger to this subcommittee. And we welcome you.

Mr. MEYERS. If you agree, I would like to submit my entire statement for the record.

Mr. LUNDINE. Without objection, the entire statement will be made a part of the record. And you may summarize or proceed as you wish.

Mr. MEYERS. Mr. Chairman and members of the subcommittee, I am pleased to appear before you today to discuss the Department of Energy's commercial nuclear waste management program and the interim spent fuel management system program.

Within the scope of the commercial nuclear waste management program, DOE is responsible for disposing of high-level radioactive waste from civilian uses of nuclear power, including carrying out a high-level liquid radioactive waste management demonstration project near West Valley, N.Y.

As to commercial spent fuel, prior year programs have focused on preparations for federally provided, away-from-reactor spent fuel storage. These activities are being discontinued. The spent fuel storage program is being refocused to concentrate on the development of alternative spent fuel storage techniques to enhance utility-provided storage capabilities.

The policy with regard to nuclear waste will continue to be directed toward the protection of public health and safety now and in the future.

The program that I will describe today reflects a growing understanding of the issues that must be satisfactorily resolved in order to proceed with the siting of waste disposal facilities. It is also directed toward obtaining the required approval of permanent disposal facilities from the Nuclear Regulatory Commission.

The terminal isolation program is directed toward use of mine repositories in deep geologic formations in the continental United States.

A final environmental impact statement, published in October 1980, examined the several alternative technologies for terminal isolation and the analysis concluded that there are no environmental issues that would preclude a program strategy based on disposal of waste in deep geologic repositories. A formal record of decision will be issued shortly.

Under the terminal isolation program, the necessary research and development to identify sites for repositories and to develop technology necessary for the design, licensing, construction, and operation of a geologic repository is being conducted. The repository will be designed to accept both solidified high-level waste and transuranic waste. The repository could also accept unreprocessed spent fuel if the disposal of such material were deemed appropriate.

The program has now reached the point where detailed evaluations of a limited number of potential locations can be accelerated. The Nuclear Regulatory Commission has recently issued a procedural regulation which requires that exploratory shafts be sunk to allow underground investigation of sites prior to their consideration for licensing.

By focusing our attention on sites that are most likely to be qualified, we intend to be able to sink such exploratory shafts at three possible sites within the next several years. The evaluation of sites using these exploratory shafts will allow the designation of one site at which a test and evaluation facility can be constructed with a capability to accept several hundred packages of radioactive material in multibarrier waste packages. Waste in such a facility will be part of a step-by-step program to gain experience with waste emplacement and to gain information for final decisions to construct full-scale licensed facilities.

While expediting the determination of sites, we recognize a need to continue a wider national screening for sites appropriate for a system of repositories that are regionally based.

As part of this nationwide screening, in 1980, a survey of crystalline rocks throughout the United States resulted in a recommendation to study further the southern extension of the Canadian Shield underlying the Lake Superior region and the rocks of the northern and southern Appalachians. Letters were sent to the Governors of the 16 concerned States, providing draft copies of technical documents describing the basis for this recommendation, and requesting the participation of State authorities in reviewing the available information and planning further studies. This activity is now beginning with various State officials and agencies.

Field investigations of salt domes in the Gulf Interior Region of Texas, Louisiana, and Mississippi have progressed to enable recommendations of which domes should be the subject of more intensive study. The basis for these recommendations is now being discussed with State officials to allow intensive studies to begin this summer. Investigations of the Paradox Basin in Utah and portions of the Permian Basin in Texas are continuing. Those are bedded salt formations.

During the next year, we will need to decide which of the various salt formations should become the focus of our investigations and whether others should be dropped from further consideration.

We are also continuing our evaluation of the potential of deep basalt formations below the Hanford site in the State of Washington and the suitability of volcanic tuffs on the Nevada test site in southern Nevada.

The Hanford studies have led to identification of a 70-mile area designated as the Cold Creek Syncline, as the most suitable for possible location of a repository site. At the Nevada test site, Yucca Mountain is the site of detailed investigation of thick sections of volcanic rock.

During 1980, an R. & D. facility involving emplacement of radioactive materials began operation. Eleven spent fuel elements obtained from a commerical power reactor were hermetically sealed in stainless steel containers and emplaced in the Climax granite formation 1,500 feet below the surface at the Nevada test site.

This facility, which is designed to simulate the spacial and thermal conditions of a full-scale repository, has provided not only technical information about the thermal and radiation effects on granite, but has also served as a major asset in communicating to the public the nature of a repository.

The Climax facility has been visited by members of the public, by local and national political leaders and by representatives of foreign governments. In 1980, over 70 tours were conducted to allow over 1,000 people to see the facility.

In July of 1980, the first of a series of experiments on basalt was initiated in the Near Surface Test Facility (NSTF) on the Hanford site. The experiments, using electrical heaters, are the first to determine the response of basalt, on a large scale, to high temperature waste canisters.

The data from this experiment will provide the initial basis of the design of the emplacement methods and configuration for the waste, as well as experimental confirmation of the thermal conditions that the waste packages could encounter in a basalt repository.

Those experiments at the NSTF are closely related to those conducted in a granite formation at the Stripa mine in Sweden that we initiated 3 years ago. In 1980, we brought to a successful conclusion the first phase of the program at Stripa, which will establish some of the basic technology for analyzing the effect of temperature on hard-rock formations.

The major success of these experiments was the confirmation of a reliable method for calculating temperature distribution, and the analysis of stresses and deformations created in the granite formation. These are important factors in the design of a safe repository in hard rock.

Turning now to low-level waste, the Radioactive Waste Policy Act, Public Law 96–573, enacted last year, established as Federal policy that each State is responsible for providing for the disposal of non-Federal, low-level radioactive waste generated within its borders.

In fiscal year 1982, the Department will assist the various States in meeting their responsibilities in this area, including helping them to establish functional systems for treatment and disposal of commercial low-level waste. Planning and other support will be provided to States in their effort to develop regional disposal sites.

Now, Mr. Chairman, with regard to West Valley, which I know you have an interest in, the West Valley Demonstration Project Act, passed in 1980, directed the Department of Energy to carry out a high-level liquid waste solidification project at West Valley, N.Y.

The purpose of this project is to demonstrate solidification techniques which can be used for preparing high-level radioactive waste for disposal. It is a research and development project which in no way relates to the remedial action program.

In November 1980, as directed by the act, DOE entered into a cooperative agreement for the demonstration project with New York State. This past February the Department issued a request for proposal for an operating contractor.

In fiscal year 1982, the Department of Energy will assume responsibility for management of the West Valley site, with the exception of the New York State-licensed burial ground, and will begin preparing the site for the demonstration.

A conceptual design of a solidification facility will be prepared, and the environmental impact statement for the project will be completed and necessary safety analyses performed. Mechanisms will be developed to transfer the technology from this demonstration project to other HLW locations.

Now, with regard to the Department's interim spent fuel management program, as I mentioned earlier, prior year programs have focused on preparations for federally provided away-from-reactor commercial spent fuel storage. These activities are being discontinued.

Under the interim spent fuel management program, our activities are being refocused to concentrate on the development of alternative spent fuel storage techniques to enhance utility-provided capabilities. Dry storage, fuel disassembly, and rod storage technologies will be developed. These alternative storage technologies have the potential to greatly enhance the storage capacities of the utilities.

The activities of the international storage program will include the support of international organizations and the completion of multinational storage studies. These studies are based on previous commitments by the United States and do not specify any course of action on international spent fuel storage.

Mr. Chairman, I would now like to summarize some of the more important accomplishments of the commercial nuclear waste program:

We have conducted site field evaluation activities in six States. We have successfully narrowed investigations at the Nevada test site to a single site—Yucca Mountain. We have successfully narrowed investigations at Richland to a 70-square-mile area—Cold Creek syncline.

We have initiated thermal testing at the near surface test facility, near Richland, Wash.

We have initiated thermal and radiation testing in the climax facility, at the Nevada test site.

We have provided assistance to States and regional groups to develop low-level waste plans.

Mr. Chairman, in summary, I have tried to share with you today some of the current major thrusts and decisions that have been taken by the administration with regard to our waste management programs. I shall be pleased to try to answer any questions that you might have at this time.

[The prepared statement of Mr. Meyers follows:]

Statement of Sheldon Meyers
Deputy Assistant Secretary for Nuclear Waste Management
Department of Energy
Before The
Energy Research and Production Subcommittee
House Committee on Science and Technology
March 19, 1981

## COMMERCIAL NUCLEAR WASTE MANAGEMENT PROGRAM/ INTERIM SPENT FUEL MANAGEMENT PROGRAM

Madam Chairman and Members of the Subcommittee, I am pleased to appear before you today to discuss the Department of Energy's Commercial Nuclear Waste Management Program and the Interim Spent Fuel Management Program.

Within the scope of the Commercial Nuclear Waste Management Program DOE is responsible for disposing of high-level radioactive waste from civilian uses of nuclear power including carrying out a high-level liquid radioactive waste management demonstration project near West Valley, New York, under the provisions of the West Valley Demonstration Project Act (P.L. 96-368). As to commercial spent fuel, prior year programs had focused on preparations for Federally provided away-from-reactor (AFR) spent fuel storage. These activities are being discontinued. The Spent Fuel Storage Program is being refocussed to concentrate on the development of alternative spent fuel storage techniques to enhance utility provided storage capabilities.

The policy with regard to nuclear waste will continue to be directed toward the protection of public health and safety now and in the future. The program that I will describe today reflects a growing understanding of the issues that must be satisfactorily resolved in order to proceed with the siting of waste disposal facilities. It is also directed toward obtaining the required approval of permanent disposal facilities from the Nuclear Regulatory Commission.

## COMMERCIAL WASTE MANAGEMENT

This activity includes Terminal Isolation, Waste Systems Evaluation and Public Interaction, Waste Treatment Technology, and West Valley Demonstration Project. The budget request for FY 1982 is $240 million, as compared to $201 million appropriated for FY 1981.

## TERMINAL ISOLATION

The terminal isolation program is directed toward use of mined repositories in deep geologic formations in the continental United States. A final environmental impact statement, published in October 1980, examined the several alternative technologies for terminal isolation and analysis concluded that there are no environmental issues that would preclude a program strategy based on disposal of wastes in deep geologic repositories. A formal record of decision will be issued shortly.

Under the terminal isolation program, the necessary research and development to identify sites for repositories and to develop technology necessary for the design, licensing, construction and operation of a geologic repository is being conducted. The repository will be designed to accept both solidified high-level waste and transuranic waste. The repository could also accept unreprocessed spent fuel, if disposal of such materials were deemed appropriate.

The program has now reached the point where detailed evaluations of a limited number of potential locations can be accelerated. The Nuclear Regulatory Commission (NRC) has recently issued a procedural regulation which requires that exploratory shafts be sunk to allow underground investigation of sites prior to their consideration for licensing. By focusing our attention on sites that are most likely to be qualified, we intend to be able to sink such exploratory shafts at three possible sites within the next several years. Enough information is now available for the Department to determine which sites will meet generalized standards compatible with those under development by the Environmental Protection Agency (EPA) and NRC.

The evaluation of sites using these exploratory shafts will allow the designation of one site at which a test and evaluation facility can be constructed with a capability to accept several hundred packages of radioactive materials in multi-barrier waste packages. Waste in such a facility will be part of the step-by-step program to gain experience with waste emplacement and to gain information for final decisions to construct full-scale licensed facilities.

While expediting the determination of sites, we recognize a need to continue a wider nationwide screening for sites appropriate for a system of repositories that are regionally-based. As part of this nationwide screening, in 1980 a survey of crystalline rocks throughout the United States resulted in a recommendation to study further the Southern extension of the Canadian Shield underlying the Lake Superior region and the rocks of the Northern and Southern Appalachians. Letters were sent to Governors of the 16 concerned States providing draft copies of technical documents describing the basis for this recommendation and requesting the participation of State authorities in reviewing the available information and planning further studies. This activity is now beginning with various State officials and agencies.

Field investigations of salt domes in the Gulf Interior Region of Texas, Louisiana and Mississippi have progressed to enable recommendations of which domes should be the subject of more intensive study. The basis for these recommendations is now being discussed with State officials to allow intensive studies to begin this summer. Investigation of the Paradox Basin in Utah and portions of the Permian Basin in Texas is continuing. During the next year we will need to decide which of the various salt formations should become the focus of our investigations and whether others should be dropped from further consideration.

We are also continuing our evaluation of the potential of deep basalt flows below the Hanford Site in the State of Washington and the suitability of volcanic tuffs on the Nevada Test Site in Southern Nevada. The Hanford studies have led to identification of a 70-mile area, designated as the Cold Creek Syncline, as the most suitable for possible location of sites. At the Nevada Test Site, Yucca Mountain is the site of detailed investigation of thick sections of volcanic rock.

In the area of technology development, work continues in both broad, long-term generic and rock specific investigation. During FY 1981 we have concentrated our efforts on: (1) development of mathematical modeling technology needed to confirm the acceptability of a site, (2) evaluation of the engineered multi-barrier materials and waste forms to provide packages which assure containment of waste during the initial period of high radioactivity, and (3) evaluation of the design requirements for each rock type being considered for a repository.

During FY 1982, technology studies will be needed to: (1) apply the newly developed mathematical models to calculation of specific site characteristics, (2) initiate extensive tests of the durability and compatability of candidate materials for multi-barrier waste packages including the hot cell testing of small scale canisters, (3) select the temperatures and other conditions acceptable for operation of a repository in each type of rock, and (4) conduct design studies, particularly on repository construction in basalt, as has already been done for repositories in salt.

During 1980, an R&D facility involving emplacement of radioactive materials began operation. Eleven spent fuel elements obtained from a commercial power reactor were hermetically sealed in stainless steel containers and emplaced in the Climax granite formation 1500 feet below the surface at the Nevada Test Site. This facility, which is designed to simulate the spacial and thermal conditions of a full-scale repository, has provided not only technical information about the thermal and radiation effects on granite, but has also served as a major asset in communicating to the public the nature of a repository. The Climax facility has been visited by members of the public, by local and National political leaders and by representatives of foreign governments. In 1980, over 70 tours were conducted to allow over 1000 people to see the facility.

In July of 1980, the first of a series of experiments on basalt was initiated in the Near Surface Test Facility (NSTF) on the Hanford Site. The experiments, using electrical heaters, are the first to determine the response of basalt, on a large scale, to high temperature waste canisters. The data from this experiment will provide the initial data for the design of the emplacement methods and configuration for the waste, as well as experimental confirmation of the thermal conditions that the waste packages could encounter in a basalt repository.

These experiments at the NSTF are closely related to those conducted in a granite formation at the Stripa Mine in Sweden that we initiated 3 years ago. In 1980, we brought to a successful conclusion the first phase of the program at Stripa, which will establish some of the basic technology for analyzing the effect of temperature on hard-rock formations. The major success of these experiments was the confirmation of a reliable method for calculating temperature distribution, and the analysis of stresses and deformations created in the granite formation. These are important factors in the design of a safe repository in hard rock.

## WASTE SYSTEMS EVALUATION AND PUBLIC INTERACTION

This activity provides for State participation in planning and implementation of the site qualification and selection program for a commercial waste repository. With State assistance, the commercial repository program, as well as other aspects of the Commercial Nuclear Waste program, can be tailored to encourage political and public support. Discussion and analysis over the past year have led to a better understanding of the elements of interaction between Federal and State governments which can lead to the successful siting of permanent waste management and disposal facilities. We note that both houses of Congress passed legislation last year with provisions for stronger State and Federal interactions.

During the past year, a number of grants have been provided to State governments for their independent review of the DOE waste management program and for workshops and meetings with the public. These extremely important programs have provided a method for State officials to participate in site screening programs and have enabled members of the public to learn the essentials of the technology and proposed programs.

A number of States, particularly those with active programs related to siting of high-level waste repositories or low-level waste (LLW) burial grounds, are seeking to establish support through the National Governors' Association for sharing ideas on constructive State/Federal interlations. This is evidence of wide recognition of the principle of a shared responsibility for finding solutions to waste management problems.

The Waste Systems Evaluation activity also includes funds for support in the areas of quality assurance; independent assessment and evaluation of the feasibility, economics, and safety of alternative waste management systems; and maintenance of a program for integrating and supporting the international nuclear waste management activities concerned with bilateral and multinational information exchanges and cooperative R&D programs.

The FY 1982 efforts will include: (1) quality assurance assistance to nuclear waste management programs in the form of personnel training, recommendation of appropriate methods and procedures, preparation of documentation, implementation of standards, and the conduct of audits; (2) waste management studies to provide cost estimates and technical assessments; (3) continued efforts toward the development of improved methodology for nuclear waste management system safety assessments; (4) preparation of updates of the "International Waste Management Source Book"; (5) continued review of waste management programs and projects by the National Academy of Sciences' Committee on Radioactive Waste Management.

## WASTE TREATMENT TECHNOLOGY

The objective of this program is to develop a technology for immobilizing waste from nuclear fuel cycles and to convert it to forms which provide safety and economy of management, satisfy regulatory requirements, and are acceptable for disposal. Processes deal with a variety of wastes: high-level, low-level, transuranic (TRU) contaminated solids, and gases. Each of these waste types requires processes that reduce the volume or convert the materials into stable, less dispersable forms for safe transport and/or long-term isolation. These waste forms will provide one of many barriers to the release of radioactivity to the environment.

During FY 1982, high-level waste form properties that have been confirmed by the Materials Characterization Center at Pacific Northwest Laboratories in Hanford, Washington, will be documented as part of the program close out. High-level waste form development will continue under the Department's Defense Waste Program, and will be adapted for commercial waste when needed. Transuranic waste technology (TRU) development in FY 1982 will focus on incorporating TRU waste into forms which are acceptable for safe transporation and disposal.

The Low-Level Radioactive Waste Policy Act, P.L. 96-573, enacted last year, established as Federal policy that each State is responsible for providing the disposal of non-Federal low-waste generated within its borders. In FY 1982, the Department will assist the States in meeting their responsibilities in this area, including the establishment of functioning systems for treatment and disposal of commercial low-level waste. Planning and other support will be provided to States in their effort to develop regional disposal sites.

International cooperative and information exchange programs during FY 1982 will enable a more rapid exchange of new airborne waste technology information, and will assist in the development of criteria for acceptable storage forms for gaseous waste products.]

## CLEANUP AT THREE MILE ISLAND II

In FY 82 the waste management program will continue a series of R&D activities to assist in the cleanup at Three Mile Island (TMI) II.

We are developing accident related waste treatment technology which will be made available to the commercial sector and will demonstrate solidification of abnormal nuclear wastes generated as a result of the TMI accident. An experimental program has been set up to solidify inorganic and organic resins from TMI--which exemplify these abnormal wastes. We will use resins from the EPICOR and submerged demineralizer system as feed material for the solidification system. We will test for batch-to-batch variations, perform confidence testing, and observe long-term stability of the product. We expect to demonstrate the technology to solidify abnormal wastes such as those produced at Three Mile Island. This R&D activity contributes to the cleanup of the Three Mile Island facility, since it will resolve at least one of the issues that threaten to hamper the cleanup process.

We are also studying the design requirements for overpacks for shipping the contaminated resins to their destinations.

## WEST VALLEY DEMONSTRATION PROJECT

The West Valley Demonstration Project Act, passed in 1980, directed the Department of Energy to carry out a high-level liquid waste solidification project at West Valley, New York. The purpose of this project is to demonstrate solidification techniques which can be used for preparing high level radioactive waste for disposal. It is a Research and Development project which in no way relates to the Remedial Action Program. In November 1980, as directed by the Act, DOE entered into a cooperative agreement for the demonstration project with New York State officials. This past February, the Department issued a Request For Proposal for an operating contractor.

In FY 1982, the Department of Energy will assume responsibility for management of the West Valley Site, with the exception of the New York State-licensed burial ground, and will begin preparing the site for the demonstration. A conceptual design of a solidification facility will be prepared and the Environmental Impact Statement for the Project will be completed and necessary safety analyses performed. Mechanisms will be developed to transfer the technology from this demonstration project to other HLW locations.

Let us now consider the Department's Interim Spent Fuel Management Program.

## INTERIM SPENT FUEL MANAGEMENT PROGRAM

As I mentioned earlier prior year programs have focused on preparations for Federally provided away-from-reactor commercial spent fuel storage. These activities are being discontinued. Under the Interim Spent Fuel Management Program our activities are being refocused to concentrate on the development of alternative spent fuel storage techniques to enhance utility provided capabilities. Dry storage, fuel disassembly, and rod storage technologies will be developed. The advanced storage technologies have the potential to greatly enhance the storage capacities of the utilities. The activities in the international storage program will include the support of international organizations and the completion of multinational storage studies. These studies are based on previous commitments by the United States and do not specify any course of action on international spent fuel storage.

## SUMMARY OF RECENT ACCOMPLISHMENTS

Mr. Chairman, I would now like to summarize some of the more important accomplishments of the Commercial Nuclear Waste Program:

- Conducted site field evaluation activities in six States
    - Successfully narrowed investigations at the Nevada Test Site (NTS) to a single site - Yucca Mountain
    - Successfully narrowed investigations at Richland to a 70-square-mile area - Cold Creek Syncline
- Initiated thermal testing at the Near Surface Test Facility (Richland)
- Initiated thermal and radiation testing in the Climax Facility (NTS)
- Provided assistance to States and regional groups to develop low-level waste plans

### SUMMARY

Mr. Chairman, in summary, I have tried to share with you today some of the current major thrusts and decisions that have been taken by the Administration with regard to our waste management programs. I shall be pleased to try to answer any questions that you might have at this time.

Mr. LUNDINE. Thank you very much. I would like to ask you some questions about your proposed research and development test facility included in the current budget proposal for fiscal year 1982.

First of all, how does this test facility you are proposing differ from the work you have described at the Nevada test site, Hanford, and Stripa? I mean, you described all of the worthwhile work going on at these various sites, and then you are coming in with a new proposal for research and development. And I'm not certain how the latest proposal relates or takes us further than the research at these three existing projects.

Mr. MEYERS. The Stripa facility has no radioactive material in it, merely heater elements. The near-surface test facility in basalt currently only has heater elements in it as well. The Nevada test site does have 11 spent fuel elements and perhaps 26 heater elements in it.

Now the facility we're talking about is the next step up. It would have emplaced in it several hundred canisters of waste. We would expect to be able to develop the engineering for the various pieces of equipment and designs for a full-scale repository from that.

Mr. LUNDINE. Why wouldn't you just put the waste in the existing sites? Is this new proposal to be more sophisticated in some way?

Mr. MEYERS. Well, one difference is that neither the near-surface test facility in basalt nor the climax facility, as best we know now, are suitable for expansion into a full-scale repository. One of the features of this test facility is that we intend to go through rigorous analysis for selecting the site so that it could be expanded into a full-scale repository.

Mr. LUNDINE. So it might be expanded. It is not strictly a forever research and development project.

Mr. MEYERS. That's correct. If everything works out properly, we will have NRC involved along the way in terms of exchange of information and review of reports, so that if it appears to be the best approach, then it could be expanded into a full-scale repository. And if that were the case, we would then go forward to NRC with a license application.

Mr. LUNDINE. What about the role of the States? What role do you expect the States to play in the siting of such a test facility?

Mr. MEYERS. As you know, we have a long-standing agreement with the various States that they designate who they want us to discuss things with. We work sort of at their option. The idea would be that they designate officials we can deal with, and we work with them in the sense of providing early information and solicit their advice as to the approaches we are taking. In many cases, we have provided independent funding so that they can analyze the work we are proposing and not have to rely on the fact that we say it is all right.

Mr. LUNDINE. Are they going to have veto power?

Mr. MEYERS. As you probably recall from the last hearing, we were talking about a scheme of consultation and concurrence, and Congressman Dingell reminded us that concurrence implies possible nonconcurrence, and nonconcurrence is a veto. And he has sent us a GAO report which essentially said that we have no authority to give States a veto. So under our scheme, we would like to work with the States and satisfy their concerns and hopefully never get to the point where they say, "We don't want you here."

Mr. LUNDINE. Finally on this subject, how would this test facility that you are proposing for the fiscal year 1982 budget compare with the research and development repository concept embodied in Mrs. Bouquard's proposed legislation, H.R. 1909?

Mr. MEYERS. Well, I haven't digested that bill completely, but as I recall, it precludes the research and development facility from being a full-scale repository, so that is one major difference. If we are to site a research and development facility properly, we have to go, as I said, with the same rigorous analysis that we would for a full-scale repository, and I would not like to waste a site by agreeing in advance that after we have gone through that exercise, it will never be a full-scale repository.

Mr. LUNDINE. I have further questions, but my 5 minutes are up. And to be fair, I think we should recognize others.

Mr. Forsythe?

Mr. FORSYTHE. Thank you, Mr. Chairman. And thank you for your testimony, Mr. Meyers.

Maybe you answered this earlier, but in your opening paragraph on terminal isolation, you talk about deep geologic repositories. How deep is that—1,500 feet or more?

Mr. MEYERS. It will be deeper than that. It will be more like 2,000, 2,600, 3,000 feet. I should say that the reason we were able to utilize, as quickly as we did, the climax facility is that it is on the Nevada test site, which is a weapons test site, and we just lucked out in that the military had drilled this shaft as part of a facility for one of its weapons tests. We were able to get down to 1,500 feet rather rapidly and put that test facility in. And it is quite impressive, I must say.

Mr. FORSYTHE. In the next paragraph you referred to the sinking of exploratory shafts at three possible sites within the next several years.

Could you be more specific as to what "several" means?

Mr. MEYERS. Well, we would expect to have the shaft sunk in the next 2 or 3 years. And the reason that we can't be precise is that we intend to work with NRC in a way that they would be comfortable with our coming later with a license application for such a facility, but not have this initial test facility licensed. We would have to work at their pace.

Mr. FORSYTHE. What is the impact of the budget situation in terms of the timing? Is that part of the problem?

Mr. MEYERS. No; the program I have described to you has been supported by the new administration. In fact, they increased our budget to allow that to happen.

Mr. FORSYTHE. Talking about the 16 States—and I gather quite a number of those are in the Northeast—could you be specific for me, at least for the Northeastern States?

Mr. **Meyers**. Sure. Those 16 States include the Canadian Shield, Michigan, Minnesota, and Wisconsin. Then from Maine down to Georgia, the 13 States right down the Appalachian Mountains, are all granite. Now it is important for you to know that the test sites in the other locations I've mentioned earlier are all out West—Nevada, the State of Washington, Utah, and also the gulf coast of the United States The preponderance of the reactors are on the east coast, and in terms of regional repositories, that sort of makes sense to us.

Mr. **Forsythe**. You were working with Sweden on this one development program. Where are we in terms of this technology for high-level waste disposal with some of the other nations? I understand that other nations are really way ahead of us and have resolved to go with technologies as they are now and are not still searching. At least they are satisfied to really start putting wastes in long-term storage.

Mr. **Meyers**. Well, that's not quite the way it is.

Mr. **Forsythe**. How is it?

Mr. **Meyers**. There are nations in the industrialized world which have nuclear plants and have problems similar to ours in terms of waste disposal. Now in Europe, the European Economic Community has banded together to mount a program similar to ours. England, France, Germany, all the EEC countries, have sort of split amongst themselves—depending upon their own geologies—the search for a respository. They all agree that deep geologic disposal is the way to go.

Britain, for example, is looking at granite. France is looking at granite as well. Germany and the Netherlands are looking at salt. Belgium and Italy are looking at clay. So they have distributed amongst themselves, and they are behind us in terms of finding a site to dispose of their waste.

Now where there is more of an advancement on the part of the Europeans is in France. The French have an operation, a facility to solidify liquid high-level waste. They have a reprocessing plant not far from Marseille, and they have added a vitrification plant which is designated AVM—Atellier Vitrification Marcoux. That plant has been in operation for the last year, but all that it does is convert the liquid waste to vitrified waste which they store on site; it is temporary storage. They make no claim that that will be the final disposal.

Now we have run a smaller version of that plant at our Pacific Northwest Laboratory where we have reprocessed spent fuels and ended up with several canisters of waste. We have a very large development program under our defense program which has generated literally some 70 million gallons of high-level waste in liquid, sludge, and salt forms at Hanford and Savannah River, and at Savannah River we have a rather extensive engineering development program where solidification components are being fabricated now in full scale.

Now we have under design a rather large facility that will vitrify or solidify that liquid waste in the future, but in terms of technology, we have the technology. It is a matter of getting on with it.

Mr. **Forsythe**. Vitrification is for sure the way to go?

Mr. **Meyers**. Well, that is a way. We are looking at alternative waste forms as well, at least one other. And in 1983 we intend to select the particular waste form that we will use, and then we will be ready to go.

I should add, the facilities that we're talking about are rather expensive facilities.

Mr. **Forsythe**. Have you so far gotten good cooperation from the States that are involved in the Appalachian and the Canadian shield and so forth, or is it too early to make an assessment?

Mr. **Meyers**. In those States, we are at the paper study stage, and I am intimately involved in that since I called the Governors' offices myself when we were ready to send them the letters, and they were all willing to cooperate, and it was very clear, of course, to them that at least for this coming year, this was just going to be paper studies.

I should also tell you that once we get to the point where we show up with drill rigs, then there is a different attitude on the part of the various States. Everybody agrees that we need to find a solution to the problem and we ought to do it in a technically sound way, but not in their State.

Mr. **Forsythe**. Many things work that way. Thank you, Mr. Chairman.

Mr. **Lundine**. Mrs. Bouquard?

Mrs. **Bouquard**. Thank you very much, Mr. Chairman.

Mr. Meyers, you were referring to alternate methods of waste disposal just now. The Deputy Assistant Secretary for Nuclear Waste Management reports on the civilian and defense waste programs separately within the Department of Energy. If this organizational arrangement is disallowed so that each activity is isolated from the other within the DOE, how is this going to impact the cost and the schedules of our civilian R. & D. programs—for instance, our access to the applied technology that our civilian program has benefited from?

Mr. **Meyers**. Mrs. Bouquard, I am hardly a disinterested third party.

Mrs. **Bouquard**. I'm very much aware of your interest.

Mr. **Meyers**. Since I am the individual that heads that joint office.

Mrs. **Bouquard**. Yes, I know.

Mr. **Meyers**. And I felt strongly that it should not be separated. It would be an inefficient way of conducting business; however, if it did happen, I must tell you that I would do everything within my power to see that it operated as effectively as it could. In other words, we would try to open ties with the other parts of the program so that transfers of technology did take place. But it is going to be a mess if that does happen. It is not only the headquarters function, but it is a field function as well.

You could get into a situation where two different people with the same kind of job were directing field activities, and who sets the priority? Do you have a field manager try to decide which is more important, or do you have a person in Washington say, "Here is my ordering of priorities for waste management"? So it is a fairly complicated situation, if it does take place, and I think the negative ramifications of that happening are really unknown at this time.

Mrs. **Bouquard.** I really think it would be a tragedy to waste our R. & D. dollars in this fashion.

Mr. **Meyers.** I agree. It may not ever get to the point where we have parallel R. & D. programs. I don't know if you caught the nuance of this testimony, but on the commercial side we have terminated the solidification program because we have a very active program on the defense side that is directly transferable. The selection of the waste form in 1983 is being done in the defense program, and that form will be used for West Valley.

Just as a matter of interest, we had a hearing with the Armed Services Committee last week, and at least half the questions were on the commercial program. I couldn't help thinking that if we had separated the programs, whoever was sitting there would have had to say, "Gee, I would like to answer your question, but you will have to get the other guy."

I just don't think it makes sense. The arrangement we now have is responsive to the law and is working.

Mrs. **Bouquard.** I thank you for your concern and your input in this area. Previously, DOE's analysis showed that even with reracking and other spent fuel economy measures, there is a need for AFR storage, as you know, in the late 1980's and early 1990's. Now that DOE has presumably abandoned a position of confidence in this matter, where will the needed storage be found?

Mr. **Meyers.** Well, the need is still there, and the approach now is to essentially turn it over to industry. If you will recall, one of the reasons we had the problem with spent fuel building up was, the past Administration in April of 1977 put an indefinite deferral on reprocessing. Now I understand that this Administration will lift that ban, and the commercial sector will be allowed to have reprocessing. If that does take place, the timing is such that a facility could be on line before that glut hits the market.

Mrs. **Bouquard.** Don't you think we should be making similar provisions, in case we don't get our time frames to correlate?

Mr. **Meyers.** As I said, we have a number of programs underway that could assist in interim storage techniques, that would allow the utilities to get more spent fuel in the pools that they have. The dry storage techniques would allow them to add a different kind of storage technique on their sites.

But the real critical point is that the analysis we did was predicated on two factors: one, no trans-shipment among the utilities, and maintaining what we call "full-core reserve capacity," which allows the utility to transfer the complete core out of the reactor vessel. In the entire life of a reactor, that may never happen, but it's the kind of thing that is nice to have.

Now, if the utilities are pressed, they can use a full-core reserve capacity; and they can transship within their own system. What that means is that if industry does not come forward with clear, viable solutions between now and 1990, I think the Federal Government will readdress the issues.

Mrs. **Bouquard.** Thank you very much.

Mr. **Lundine.** Mr. Lujan?

Mr. **Lujan.** Thank you, Mr. Chairman.

What was it—the day before yesterday, that you told us that you abandoned the away-from-reactor storage concept? I've thought about it since then, and I am concerned. You talked about the dry storage. As a practical matter, how long will it take a utility to put in a dry storage facility?

Mr. MEYERS. That is difficult to say, Mr. Lujan.

The reason I say that is that——

Mr. LUJAN. When will you know that the research that you are working on for dry storage is all right, and perfectly acceptable for a utility? In other words when will a utility be able to go for a license, before the NRC, and expect to receive a favorable response?

Mr. MEYERS. That's why I said it is difficult. Because there has never been a licensed dry storage facility.

Mr. LUJAN. Forget the licensing.

Mr. MEYERS. We have, under test in Nevada right now, caissons with spent fuel in them, and dry holes with spent fuel in them. They are relatively simple, concrete-lined holes. And we are also working with the Germans, who have developed a casket that can be used for both storage and transportation.

If all of those are the kinds of things that one can build or put in place at a utility site, and if you use the time frame for licensing a spent fuel storage pool, you are talking about perhaps 2½ years for the licensing process.

The attractive feature about some dry-storage arrangements is that you don't have to build a big physical plant. You just add on as you need it.

Mr. LUJAN. But you have got to prove that it works. You have got to get the right kind of chemistry that you are working on.

When do you expect that you will have a solution to that problem?

Mr. MEYERS. Well, I would expect that we would be able to see that a particular dry-storage technique—such as a caisson or a hole in the ground, a dry well—in a couple of years.

Now, the other important thing is that, if the utilities really felt that they had to do something right now, they could join together or individually build another spent fuel pool which would have to be licensed.

Mr. LUJAN. But not at one place.

If you were going to do that, you could just go to Barnwell.

Mr. MEYERS. I'm saying there's nothing to stop the utilities from joining together themselves, and agreeing that they will build a centralized facility for the storage of spent fuel, someplace; or expand existing pools at their own sites.

One could build another pool.

Mr. LUJAN. Then, what you're saying is the technology is there, so they can go ahead and build, and we don't need to be involved in it?

That is the current position of the Administration.

Mr. Meyers, what is the worst position, now, for a power site, as far as their spent fuel storage? Which utility has the most serious spent full storage problem?

We want full-core reserve. Who doesn't have it? Who has it? What is the worst case?

Mr. **Meyers.** I'm not sure I have that information with me, but we can get it for you. We have a listing of the timing, and which utilities run out of full-core reserve capacity over the years.

Mr. **Lujan.** Don't you have any horror stories?

Mr. **Meyers.** There are no horror stories now, but we do have a list. The shortfall doesn't come until 1986. That is why there are no horror stories now.

Mr. **Lujan.** Every one of them has more than a full-core reserve?

Mr. **Meyers.** There may be some that are getting close now; but I can provide that list for you, for the record, later. I just don't happen to have it with me.

[The information follows:]

The following reactors are currently operating without full core reserve (FCR):

*Reactor and utility*

Brunswick 1—Carolina Power & Light.
San Onofre 1—Southern California Edison Company.
Fitzpatrick—Power Authority—State of New York.

In addition, the Dresden-1 (Commonwealth Edison) reactor is currently shut down and the reactor core has been discharged to the fuel storage basin.

Robinson 2 (Carolina Power & Light) will lose FCR with its 1981 discharge but will regain full core discharge capability with the completion of the planned pool capacity increase in 1982.

Mr. **Lujan.** You're not really backing away, then?

On the one hand, you say you're backing away from reactor storage. On the other hand, you say you're not backing away from it because the utilities can provide it. But all of your reasoning for backing away from it is that it is not needed.

So, on the one hand, you use the argument that you are not years away from reactor storage. And then, you also say: "Well, if they need it, they can go through with it."

Mr. **Meyers.** There are two important features.

First of all, it is needed in the future. What we are saying——

Mr. **Lujan.** Away-from-reactor storage is needed in the future——

Mr. **Meyers.** Either away-from-reactor storage, or expansion of onsite. In other words, additional capacity is needed.

Now, the difference is that we are saying that the Federal Government is not going to provide that capacity currently. We are looking to the private sector to arrange for taking up that slack, either by providing additional storage—either centrally or onsite—or reprocessing.

Mr. **Lujan.** The permanent repository. When do you envision it?

Let me just make a comment. You said things are going well with the States. You know what happened with the low-level repository, and that was military, with no licensing. That is not going well, I will tell you, from firsthand experience. So that the negotiations with the States, in my opinion, are going to be just as tough, when you start moving the drilling rigs in.

But, taking all of those things into consideration and then, these being commercial repositories, they must be licensed.

We're looking at, what, 1995?

Mr. **Meyers.** Well, the idea of this research and development—or test and evaluation—facility, which would have several hundred cannisters of waste in it—we expect to have that in operation by 1989, 1990.

Now, we could put in a license application at the same time we were filling it up, if everything looked good. So, one could put a license application in as early as that 1989 time frame.

Mr. LUJAN. Plus 12?

Mr. MEYERS. Well, it depends. It could be as long as 12 years. Our estimate is that the licensing process, barring long litigation, is about 4 years. And the construction of the repository itself is 5 to 7 years, depending upon what the geology is.

Mr. LUJAN. Would you, then, estimate that half the utilities in the country would have to expand their storage?

Mr. MEYERS. I don't recall the numbers. We do have them, and I can provide them for you. But I just don't remember them.

But I recall that, in 1990, there is perhaps a 1,200-metric-ton shortfall.

Mr. LUJAN. By 1990, there are 29 reactors that will be full. And this one has, by 1986, 7 of them, according to this chart.

Mr. MEYERS. By 1986 there would be a 120-metric-ton shortfall, as I recall. But remember, that is predicated on retaining full-core reserve capacity and, also, not trans-shipping. If you choose either one of those—and utilities could—then that shortfall would disappear.

Mr. LUJAN. My personal feeling is, you really ought to be looking at Barnwell instead of saying, well, forget about the AFR's. And let's see how we can utilize Barnwell, because I think that we're going to come to a time when we are going to need it.

Mr. GATES. We have not heard the end of Barnwell yet, Mr. Lujan, I'm sure. In the give and take, as I think I explained the other day, of a budgetary process for fiscal year 1982, the feeling of the Administration was that it doesn't seem appropriate currently for the Federal Government to subsidize the activity at Barnwell.

Mr. LUJAN. But you're talking about our discussion the day before yesterday, and that was to acquire it, with some kind of a Government corporation. And my understanding is that revenues generated from storage charged to the utilities who put spent fuel in there, will carry the cost of operation and activities like reracking. A third category to find funding was interest payments, if you were to issue bonds.

And I think, rather than saying we ought to move away from doing nothing with away-from-reactor storage, that we ought to be looking seriously at somehow getting on with the show at Barnwell. Because that is what is available.

Mr. GATES. I think there are three options, sir.

As we mentioned, one is the quasi-government type operation. Another one is a wholly commercial operation, whereby industry gets into the act. And I think a third—still potential—is for Federal acquisition. I think that is probably third in priority in the minds of the Administration today, but there are those three options.

If we can, by one of those means, acquire the Barnwell facility, primarily for its reprocessing of light water reactor fuel to move into the fast breeder idea, then of course we can do some racking and some storage of spent fuel elements at Barnwell.

Mr. LUJAN. I know my time is limited, but just one more question.

The licensing aspect—you would still have to license Barnwell, even as a Government facility, wouldn't you?

Mr. **Meyers**. If it were a research and development facility, no. If it were a commercial enterprise, yes.

The original proposal we made to the Administration was that it be acquired as a research and development facility; and then, it would not have been licensed.

Mr. **Lujan**. For reprocessing?

Mr. **Meyers**. Right.

Mr. **Lujan**. What is the thought about private enterprise doing the reprocessing?

Mr. **Gates**. I beg your pardon.

Mr. **Lujan**. What is your thought on private enterprise doing the reprocessing?

Mr. **Meyers**. Do you mean the capability?

Mr. **Lujan**. No. Somebody can do it for the Government, as well as private enterprise. But the acceptability of their doing it—we backed away from it in Barnwell.

Mr. **Gates**. I think if we can demonstrate—and I believe the Administration is moving in this direction—some consistency in Federal attitudes toward this business over the next few years, then we are going to meet one of our goals. We can do this, to reestablish in industry, confidence in the Government's ability to maintain a consistent path.

And I think, sir, that is what——

Mr. **Lujan**. But Barnwell, in testimony, you said—and I guess you were here that day—once burned, shame on you; twice burned, shame on me.

Mr. **Meyers**. I think the answer there is to see that they are not burned twice.

Mr. **Lujan**. I don't think that they will trust us enough to burn them again.

Mr. **Lundine**. I would like to ask you one question about West Valley, again. I can't let you come up here without asking one on that subject.

In your statement, you refer to this project as "research and development project, which in no way relates to the remedial action program."

Could you, Mr. Meyers, elaborate on the specific benefit this program—or this project—will have to our overall national program?

Mr. **Meyers**. Well, for one thing, I mentioned earlier that we have, in a number of places, in a research and development mode, shown that we can reprocess and solidify the waste.

In my mind, West Valley is a next step up, but in a way that we really haven't done before. By "haven't done before," I mean West Valley is a facility that ran as a reprocessing plant and is contaminated. Several hundred thousand gallons of liquid waste are in tanks. It is similar to liquid waste that we have under the Federal account.

So, for the first time, we will be moving into a facility that allows us, on a relatively large scale, to develop techniques for extracting the waste from the tanks, to solidify the waste, to design appropriate facilities, and to perform the associated decontamination.

This experience would be applicable, across the board, to the commercial sector, as well as to the other programs we have on the Government account.

Mr. LUNDINE. I want to turn to a more general matter. First of all, I want to compliment the Administration on your review and reappraisal of our policy with respect to nuclear waste and specifically in the away from reactor storage area. It seems to me that you are absolutely right when you say what is needed is a predictable regulatory environment and that that should come from the Congress as well as from the Administration so that, as much as possible, Government is sticking together and I, first of all, just want to say that I compliment you for that particular review.

But what concerns me about what you are proposing is that it is not really an integrated approach. It is one R. & D. project that should describe going further in terms of a repository than we have gone before. And I would just like to ask your response.

Mr. Lujan's questions, for example, demonstrate that there seems to be a whole area that hasn't been thought through, at least we don't have a very certain idea of how we are going to meet some of these problems. And by "we," I mean both the private sector and the Government in a cooperative way and presumably in a more certain regulatory environment.

Mr. GATES. Let me make an observation, Mr. Lundine, and then I would like Shelly Meyers to answer more specifically. In my view the program that Mr. Meyers has outlined this afternoon is a balanced, well-focused program with the goal that by the year 1995 or 2000 we're going to have our first long-term disposal facility deep underground in a geologic medium which is appropriate to that requirement.

And I believe the business of going through the preparation of the three shafts, the selection of one of those as a result of the R. & D. that is done, and the negotiation with the State will provide a focused program. If we run into problems with respect to Federal-State kind of interactions, we will be working with NRC all the way along. We can pick out one of those three sites and expand it.

Mr. LUNDINE. In my view you are concentrating on the proper priority but I'm not persuaded that there is an integrated approach, and let me ask you a specific question. What is the status of DOE's national plan for radioactive waste management?

Mr. MEYERS. Well, as you may recall, we sent it out to 50 Governors and all of the Congress about 1½ months ago, and it is being commented on. And we've gotten a number of good comments from Members of the Congress and the Governors. I forget what the cutoff date is, but it is around now. We will soon analyze the comments that have come in, reflect them in another version of the plan, reflect the new program in the plan, and then submit it to the Congress after the new Administration has had a crack at it.

But let me get back to what I think you were getting at earlier. There is a fuzzy area, but it has to do with reliance on the private sector, either to store or run a new processing plant, but the important point there is that we have a number of years before that becomes a critical problem in this loop.

We are aware of it. It is not like there is a missing link that we don't know about. We are well aware of it. And it is my estimation that if the private sector, for whatever reason, does not come forward, then the Government very likely will act. But this Administration is inclined toward giving the private sector the opportunity to act.

Mr. LUNDINE. Well, so am I. And get an effort to try to develop that kind of an integrated approach as I indicated in the statement which I did not bore you by reading at the outset. I have introduced legislation numbered H.R. 1993, which attempts to put us on a fast track toward that integrated approach. I wonder if you could comment on that. If you would do so in writing——

Mr. MEYERS. Now, we recently have gotten a copy of the bill and it is currently under review, and we will be glad to meet with you or your staff to discuss it or submit documents in writing.

Mr. LUNDINE. I appreciate that.

[Information to be furnished follows:]

Department of Energy's
Office of Nuclear Waste Management
Comments on H.R. 1993
April 6, 1981

To the best of our knowledge neither the Administration nor the Department of Energy has taken a position on H.R. 1993 (Radioactive Waste Research, Development and Policy Act) which was introduced by Mr. Lundine on March 19, 1981. The staff of the Office of Nuclear Waste Management has, however, reviewed that draft legislation. In response to Mr. Lundine's request the following specific comments on H.R. 1993 are submitted for his consideration.

## Findings and Purposes

Findings and Purposes are generally reasonable.

## Definitions

The definition of permanent repository appears to be too restrictive. The requirement to dispose "in a manner which does not permit the subsequent recovery of the materials placed in the repository" appears impossible to meet. Furthermore, the NRC, we believe, favors maintaining retrievability at least until such time as repository decommissioning is undertaken.

Other definitions appear to be appropriate.

## Title I--Repositories for Radioactive Waste and Spent Nuclear Fuel

Section 101 calls for development of a Mission Plan. This Mission Plan must be available for comment by January 1, 1982.

Items called for are desirable but the details required on so many issues would make the task of preparing such a plan by January 1, 1982 extremely difficult, if not impossible. Following are examples of detailed demands:

- identification of all scientific and technical information that must be available
- evaluation of financial, political, or institutional problems and recommendations for ways to resolve them.

Section 101(a) describes very well the detailed information concerning both resolved and unresolved issues which would have to accompany a license application. It would be extremely difficult to complete all the prescribed tasks by January 1982, thus exposing the Department to a high risk of being judged incapable because of the preparation of an inadequate report.

Section 101(b) requires that the Mission Plan be reviewed by the State Planning Council, a new Interagency Review Group, and by the NRC. Their comments must be reviewed and the plan changed accordingly within a total time of sixty days. This short period of time would be totally inadequate for such a review.

The Mission Plan becomes effective unless disapproved by Congress within sixty days. If Congress disapproves, the Department would have only 180 days to revise the plan and get it through the State Planning Council, the Interagency Review Group, and Congress. The plan is to be updated every two years by submission of a progress report to Congress with recommendations of revisions.

## Section 102--R&D Repositories

The construction and operation of research and development facilities is desirable and may be necessary. It seems, however, that such facilities could well be located at sites that might later be used for permanent repositories. The involvement of NRC that is called for should provide adequate assurance that R&D activities would not disqualify the sites for eventual use for a full-scale facility. No real purpose seems to be achieved by limiting emplacement to 40 metric tons.

It is not clear as to whether a State Review Board should have the right to negotiate an agreement concerning an R&D repository that might be built on a Department of Energy reservation such as Hanford or the Nevada Test Site. However, such an oversight may be appropriate for lands not now on Department of Energy reservations.

For the R&D repository, a considerable debate will probably occur about the condition that if the Department and the State Review Board cannot reach an agreement within six months, the Department could proceed with construction.

## Section 103

The role proposed by the intermediate scale repository seems similar to the Test and Evaluation Facility which we believe can be constructed as an extension of the site characterization activities during which NRC will be kept fully informed of all plans, proposals, and activities.

Our proposed Test and Evaluation Facility basically does what probably is intended by the proposed R&D repository in the bill. The Test and Evaluation Facility would provide the following:

1) Further verification of the suitability of the site or the type of host rock by subjecting it to actual storage operations under intensive monitoring conditions.

2) Verification of the real time handling capability of the equipment and mine operations.

3) Verification of the safety of the operations to workers and the public by actual data on exposures.

4) Verification of the feasibility of retrieval operations.

5) Data on which to base the proposed plan for a loading array for the sequence of loading in a licensed repository as the baseline for technical conservatism and stage-wise operation.

6) A base of data on experience with materials in prototype waste packages using multiple engineered barriers in actual geologic settings.

Administratively, the Test and Evaluation Facility provides:

1) An early actual facility to coordinate with NRC on how to apply regulations and to obtain the kind of data useful for licensing.

2) The means of accumulating experience useable in safety analysis reports and in licensing proceedings.

3) A focus of NWTS R&D into a real site.

4) An opportunity for expansion into a final licensed site based on the success of the Test and Evaluation Facility.

## Section 104

We fail to see a need for two intermediate scale repositories in 1987. We believe one should be sufficient.

It is not clear that intermediate scale facilities should be licensed but the idea of a preliminary license application by 1987 has merit. This would be acceptable if construction of the Test and Evaluation Facility could occur during the time that NRC was reviewing plans for the intermediate scale facility.

## Section 105

The use of an arbitration board or similar body to adjudicate objections and concerns of State governments seems appropriate. A House bill last year provided Congress such a role.

## Section 106

The creation of a State Review Board is sound in our view; but the continuation of the State Review Board, its role or its termination in the State in which a repository would be located needs further thought.

## Section 108

We agree that community impact mitigation and assistance will be required for localities affected by a repository. The concept of payments to the States in the amount which would be paid to the State if the property were subject to taxation is referred to as "payments in lieu of taxes." The Department already has authority, derived from Section 168 of the Atomic Energy Act of 1954, to make such payments in localities where the Department has acquired property previously subject to State and local taxation. While such payments will no doubt be helpful, it should be recognized that under current authority the amount of such payments would be based on the value of the land prior to it being acquired by the government. Because lands acquired for repository use may likely be remote, with limited prior tax value, these payments may do little to help the repository communities plan for and adjust to the social and economic changes likely to result from repository development.

Accordingly, we believe that provisions beyond payments in lieu of taxes are desirable and appropriate. We are still investigating the pros and cons of various mechanisms that may be appropriate for these additional provisions. We further believe that all costs expended by the government in this regard should ultimately be recovered through disposal fees charged to the waste generators (repository users). However, these fees will not likely be collected until the repository is operational, whereas impact planning and management funds will be needed earlier. Hence, there remains a need to agree on and implement a means by which these funds can be provided in the time frame needed. We expect to be able to provide recommendations in this regard within the next year.

### Section 109, page 37, line 3

The bill states that a lump sum amount will be paid by the fuel owners to the Secretary to cover disposal costs. For a utility with 400 metric tonnes of fuel in storage and a disposal cost of $200 per kilogram of spent fuel, this lump sum payment would be $80 million. Some flexibility, particularly for fuel already discharged, would be desirable. Also, the proposed procedure discussed in lines 14 to 22 on page 37 means that the total liability is not known until the fuel enters the repository. This long-term liability of unknown magnitude may make it difficult for the utilities to collect from the present ratepayers the necessary funds to cover disposal. Perhaps a more suitable arrangement is to eliminate any future surcharges or rebates. Any cost overruns or underruns could be factored in the disposal fee for future batches of fuel.

## Title II--Spent Fuel Policies

### Section 202, page 44, line 21

This sentence should be modified to clarify what is meant by "subsidize." It is not clear to what degree this precludes any Federal research and development activities on commercial reprocessing of spent fuel. The next statement on line 23 seems to indicate that research and development should continue.

### Section 202, page 45, line 5

This section appears to be misnumbered. The section on "Dry Storage for Spent Nuclear Fuel" should be numbered 203.

### Section 202 (sic), page 45, line 18

The description on page 45, line 18 of the terms of the agreement between the Department and the utility is not clear. It states that the Department will pay 75 per centum of the cost to design and construct the dry storage facility. However, the remaining 25 per centum is not discussed. The nature of the technical assistance by the Department is not specified. The actual terms and conditions of each agreement between the Department and a utility will be unique. The proposed bill should be revised to state that the Department will negotiate an agreement with each utility to share the costs of the proposed demonstration.

Mr. **Lundine**. A final question. You talked about core storage in answer to some of Mr. Lujan's questions. And I commend you for paying more attention to that than seemingly had been paid not long ago.

But what is the realistic possibility of licensing dry storage?

Mr. **Meyers**. I see no reason why a dry storage facility could not be licensed as easily as a wet storage facility. The only difference right now is that, both in this country and abroad, we have many, many years of experience in licensing activities on pool facilities which exist now. There are no dry storage facilities available to be licensed, but they are relatively simple, rather benign, and I would guess that once we have the data in from our program and we or a utility propose such a facility, I don't really anticipate that would be a great problem.

Now, one thing that we did not mention in the last session of Congress, there was a rider on one of our appropriations bills that obliges us to look at a retrievable monitored storage system which is dry and that study is under way right now. We will have an analysis of the system, plus a cost estimate of such a facility at two sites, one at Hanford and one in Nevada. We would then present that report to the Congress, and depending upon what Congress says, we would proceed further with that concept.

Mr. **Lundine**. Mr. Forsythe, do you have anything further?

Mr. **Forsythe**. No further questions.

Mr. **Lundine**. Mrs. Bouquard?

Mrs. **Bouquard**. Nothing. Thank you, Mr. Chairman.

Mr. **Lundine**. Mr. Lujan.

Mr. **Lujan**. I have nothing.

Mr. **Lundine**. Thank you very much.

Mr. **Meyers**. Thank you, Mr. Chairman.

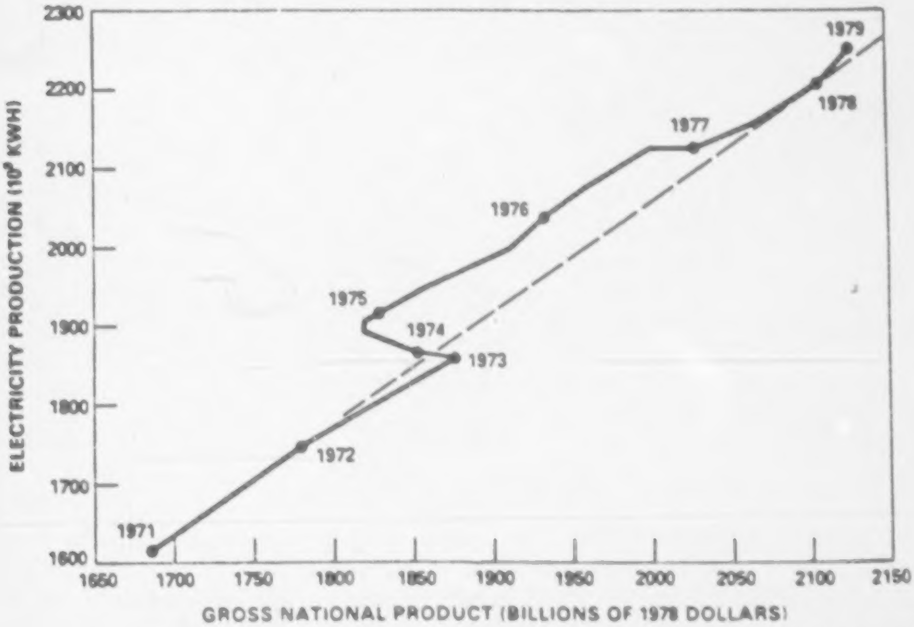
Mrs. **Bouquard** [presiding]. Thank you very much, Mr. Lundine, for your participation and your contribution in our hearings this afternoon. According to my schedule, our next witness is Dr. Tom Dillon, and I think that we will discuss at this time our nuclear reactor programs. That's the next topic of discussion. Please proceed at this time, and your testimony will be made a part of the record.

## STATEMENT OF DR. THOMAS A. DILLON, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR REACTOR PROGRAMS, DEPARTMENT OF ENERGY, ACCOMPANIED BY JERRY D. GRIFFITH, DIRECTOR OF THE OFFICE OF LIGHT WATER REACTORS; AND FRANKLIN E. COFFMAN, DIRECTOR OF THE OFFICE OF ADVANCED NUCLEAR SYSTEMS AND PROJECTS

Dr. **Dillon**. Thank you, Madam Chairman, members of the subcommittee. I'm please to appear before you to discuss the Department of Energy's conventional reactor systems program.

I am accompanied by Jerry Griffith, the Director of the Office of Light Water Reactors, and Franklin Coffman, the Director of the Office of Advanced Nuclear Systems and Projects. The major elements of our conventional reactor systems program are carried out under their direction.

It is widely recognized that a healthy economy requires an expanded use of electricity generated by coal and nuclear power in order to reduce our dependence on expensive, unreliable supplies of foreign oil. However, since this point is so fundamental to our nuclear energy strategy, I want to pause briefly to review the basic logic with these three viewgraphs.

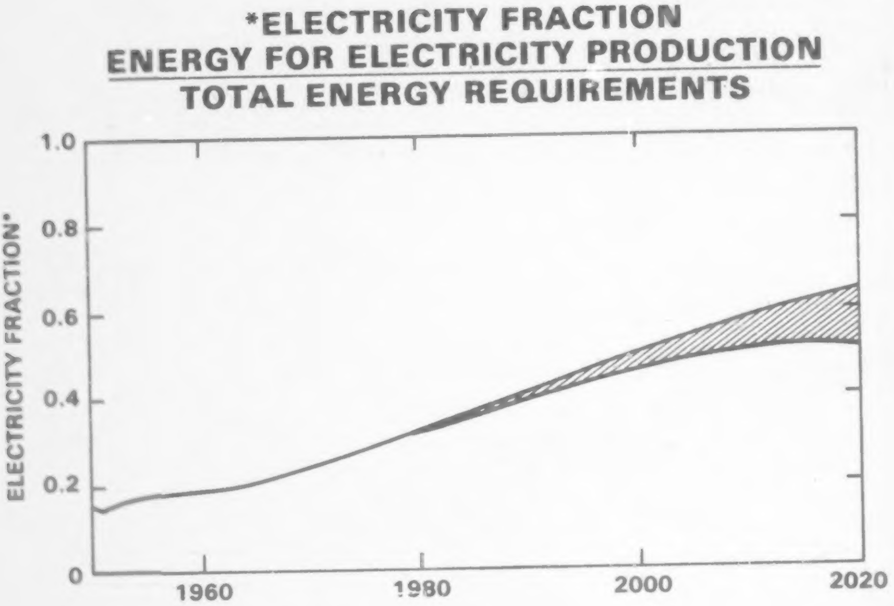


SOURCE OVERVIEW AND STRATEGY JULY 1979 ELECTRIC POWER RESEARCH INSTITUTE AS ADJUSTED

RELATIONSHIP BETWEEN GNP AND TOTAL U.S. ELECTRICITY PRODUCTION

VIEWGRAPH 1

Shown in viewgraph 1 is the historical relationship between GNP and electrical production, and we see that growing GNP is very closely tied with growth in electricity production. In fact, in some cases the growth in electricity production exceeds the growth in the GNP.



VIEWGRAPH 2

Viewgraph 2 shows another factor which I think is equally important and really, in a strategic sense, more important than the rising fraction of electricity as part of our energy budget. This is a trend which I think will continue certainly for the rest of the century and well into the next and it really reflects something that's very important: that electricity, by and large, is a domestic source of energy. I should note that although there is some oil that is used for the generation of electricity, the vast bulk of electricity itself is produced by coal, hydro, and nuclear domestic sources. So we see increased use of electricity as being a very integral part of the future. So the growth of GNP combined with this trend lead us to believe that the need for expanding supplies of electricity is an integral part of planning for the future.

| ANNUAL ELECTRICITY GROWTH MUST BE HELD BELOW (%/YEAR) | IF NUCLEAR POWER PEAKS IN THE YEAR 2000 AT (GWe) |
|---|---|
| 4.25 | 340 |
| 3.0 | 152 |
| 2.5 | 64 |
| 4.4* | 389* |

- 2 BILLION TONS/YEAR COAL PRODUCTION (780 MILLION TONS IN 1979)
- 75% OF COAL FOR ELECTRICITY PRODUCTION
- MORE THAN 90% HYDROELECTRIC POTENTIAL IN CONTINENTAL U.S. UTILIZED
- CONTRIBUTION FROM WASTE, WOOD, GEOTHERMAL, SOLAR, ETC., DOUBLES EVERY 5 YEARS
- BACK OUT OIL AND NATURAL GAS FROM PRODUCTION OF ELECTRICAL ENERGY

REF: GAO STUDY, QUESTIONS ON THE FUTURE OF NUCLEAR POWER: IMPLICATION AND TRADE-OFFS, MAY 1979

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*EPRI STUDY

VIEWGRAPH 3

Viewgraph 3 illustrates some interesting results of two recent studies, by GAO and one by EPRI. Both studies show that nuclear power will limit the total electrical growth rate that we can enjoy over the next 20 years. Now, it is very difficult to say exactly how these electrical growth rates will track the growth in our GNP, but, for example, in the EPRI study they associated 4.4 percent annual growth in electricity with a GNP growth of 2.9 percent, which certainly is a target that the Administration hopes to meet or exceed over the next 20 years. The other point I want to make is that the assumptions upon which these are based are rather optimistic in terms of increased coal production, exploitation of our hydroelectric reserves, and rapid development of geothermal, solar, and other sources of energy.

If we were to be disappointed in the growth of any of these sectors, it would increase pressure for additional nuclear generated electricity.

## OBSTACLES

- LOAD GROWTH PROJECTIONS
- NUCLEAR LICENSING UNCERTAINTIES
- UTILITY CAPITAL FORMATION
- PUBLIC PERCEPTIONS
- FEDERAL NUCLEAR POLICY

VIEWGRAPH 4

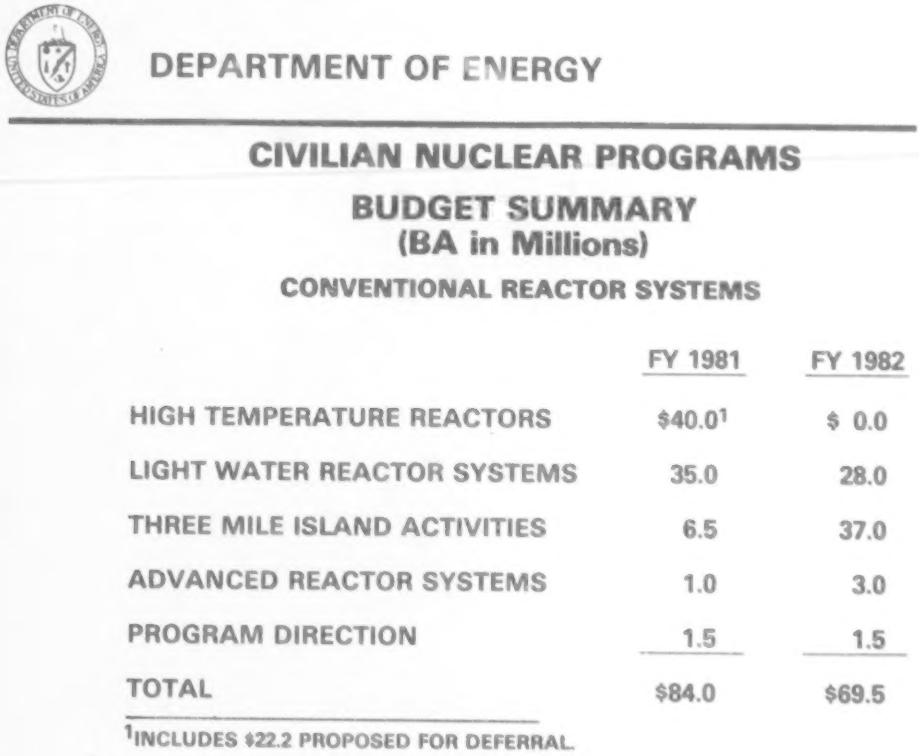
Viewgraph 4 lists some of the obstacles to nuclear growth. Dependence on foreign oil has contributed to inflation and slowed our economy, thereby reducing the demand for electricity. These effects have been compounded by problems that are inhibiting the expansion of nuclear power that is in our best national interest. Key obstacles to this expansion include a lengthy, complicated, and often uncertain licensing process; severe financial problems associated with capital formation in the electric utility industry; and a lack of public understanding and appreciation for both the benefits and the risk of nuclear power.

And finally I'm certain that our Government nuclear policy has contributed to these uncertainties. Failure to adequately deal with these obstacles has had a severe consequence. Since 1976, the Nation's utility industry has canceled over 50 nuclear plants previously ordered, and fully completed plants are currently standing idle awaiting approval from the Nuclear Regulatory Commission.

There is presently a de facto moratorium on new construction permits, and no new orders are being forecast in the foreseeable future. The time required to produce new nuclear plants has more than doubled to where it now approaches 15 years. Industrial facilities are being shut down and millions of dollars worth of partially completed components from recently canceled plants are being scrapped. The accident at Three Mile Island, and the continuing delays being experienced in cleaning up the accident indicate a serious problem with our institutional arrangements to deal with nuclear accidents. Thus, the entire U.S. nuclear industrial base capable of meeting a growth rate as high as 30 gigawatts a year is, instead, now in jeopardy.

These problems have developed over many years and their solutions will not be quick nor easy, but we must begin to act now. The new administration is committed to help get the nuclear industry back on track again. We are setting in motion the effort to regain our lead in nuclear technology and restore confidence in our commitment to rely on nuclear energy as a major contributor to our future energy supply. The programs that I will discuss with you this afternoon begin to address some of these issues. The Department will continue to evaluate the effectiveness of these conventional reactor programs in helping to restore the health of the nuclear industry. It may be necessary to modify the direction of some of these programs in the future in response to both the Administration's emerging nuclear energy policy, and in response to how effective they are in contributing to the solution of the real world problems of the nuclear industry.

The objective of the conventional reactor systems program is to enhance the use of domestic nuclear energy resources.



DEPARTMENT OF ENERGY

## CIVILIAN NUCLEAR PROGRAMS

### BUDGET SUMMARY
### (BA in Millions)

### CONVENTIONAL REACTOR SYSTEMS

| | FY 1981 | FY 1982 |
|---|---|---|
| HIGH TEMPERATURE REACTORS | \$40.0[1] | \$ 0.0 |
| LIGHT WATER REACTOR SYSTEMS | 35.0 | 28.0 |
| THREE MILE ISLAND ACTIVITIES | 6.5 | 37.0 |
| ADVANCED REACTOR SYSTEMS | 1.0 | 3.0 |
| PROGRAM DIRECTION | 1.5 | 1.5 |
| TOTAL | \$84.0 | \$69.5 |

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[1] INCLUDES \$22.2 PROPOSED FOR DEFERRAL.

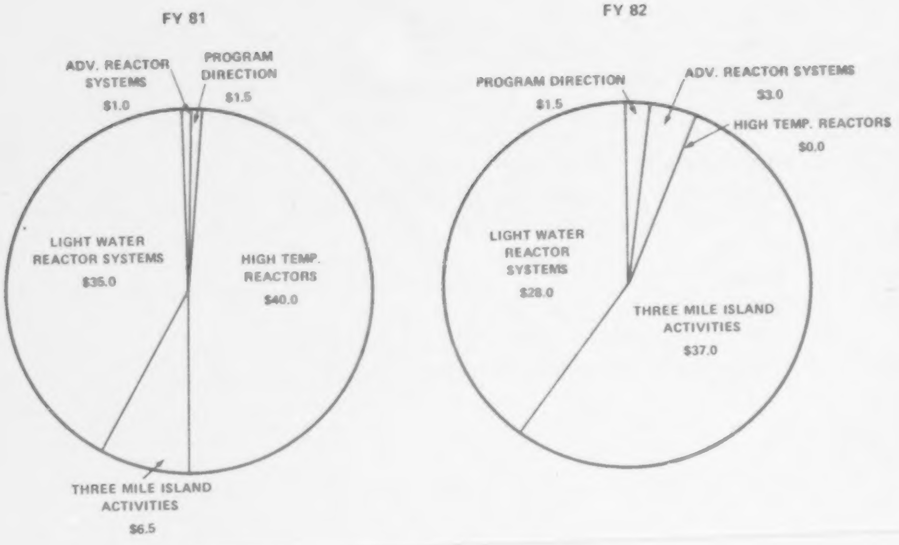
VIEWGRAPH 5

As shown on viewgraph 5, the total funding request for conventional reactor systems in fiscal year 1982 is \$69.5 million in budget authority compared to \$84 million in fiscal year 1981.

The principal difference here is that the high temperature reactor program is being terminated in fiscal year 1982 and there is a substantial increase in the Three Mile Island activities.

Madam Chairman, the remainder of my statement is rather lengthy, and I've already submitted it to you. With your permission I would like to summarize it with additional viewgraphs.

Mrs. BOUQUARD. Without objection, it will be made a part of the record.



VIEWGRAPH 6

Dr. DILLON. Viewgraph 6 shows the point that I made earlier that the high temperature reactor program which had been a very major component of the conventional reactor programs is being terminated and a rather larger share now is going to Three Mile Island activities.

Mr. LUJAN. Expand on that a little bit.

Dr. DILLON. I will be getting to the high-temperature reactor in just a minute.

Mr. LUJAN. That's all right, go ahead.

## LIGHT WATER REACTOR SYSTEMS

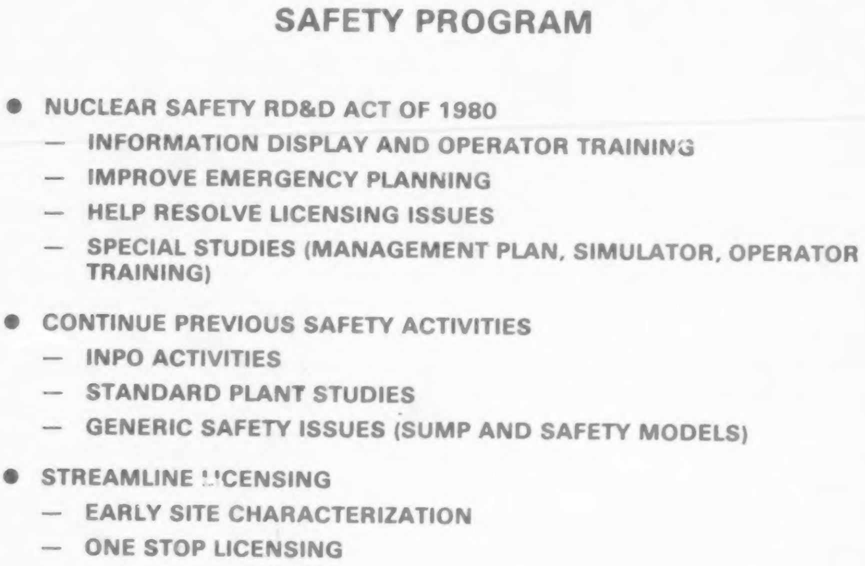
- TECHNOLOGY PROGRAMS—
  - URANIUM UTILIZATION
  - OCCUPATIONAL DOSE REDUCTION/PRODUCTIVITY IMPROVEMENT
- SAFETY PROGRAM—
  - IMPLEMENT NUCLEAR SAFETY RD&D ACT OF 1980
  - CONTINUE PREVIOUS SAFETY ACTIVITIES
  - STREAMLINED LICENSING

VIEWGRAPH 7

Dr. DILLON. First, with regard to our light water reactor systems, there are, as shown on viewgraph 7, two major components there: technology programs in uranium utilization, and occupational dose reduction and productivity improvement. During fiscal 1982 we will be completing and phasing out these very successful programs in uranium utilization.

I will describe to you in a few minutes some very encouraging results that we have gotten there. It is our belief that since substantial incentives now exist, the private sector, hopefully, will pick up on these improvements.

The occupational dose reduction area will be phasing down in fiscal 1982 and focusing in on decontamination. Dilute decontamination offers the promise of reducing exposure by as much as 60 percent, and could cut in half the total man rem exposure that is experienced in the nuclear industry.



## SAFETY PROGRAM

- NUCLEAR SAFETY RD&D ACT OF 1980
  - INFORMATION DISPLAY AND OPERATOR TRAINING
  - IMPROVE EMERGENCY PLANNING
  - HELP RESOLVE LICENSING ISSUES
  - SPECIAL STUDIES (MANAGEMENT PLAN, SIMULATOR, OPERATOR TRAINING)
- CONTINUE PREVIOUS SAFETY ACTIVITIES
  - INPO ACTIVITIES
  - STANDARD PLANT STUDIES
  - GENERIC SAFETY ISSUES (SUMP AND SAFETY MODELS)
- STREAMLINE LICENSING
  - EARLY SITE CHARACTERIZATION
  - ONE STOP LICENSING

VIEWGRAPH 8

One of the main thrusts during 1982, and I am sure it will continue in subsequent years, is our safety program as described on Viewgraph 8. One of our principal objectives this year will be to implement the terms of the Nuclear Safety R. & D. Act of 1980—Public Law 96-567. We will be continuing our previous safety activities, which have been focused on the near term issues associated with licensing.

And then, finally, we will be moving into areas that I am calling streamlined licensing approaches, and I will describe those in just a minute.

Our safety program really centers around two basic types of objectives. The first is near term. In fact, if we look very closely at unresolved safety issues, the rulemaking and the new regulations of the Nuclear Regulatory Commission, these are the activities that are going to have impact on nuclear plants in the near future.

We have several programs under way, the goals of which are to get results in a timely manner so that we can have a positive input to these various rulemakings as they unfold over the next 2 or 3 years. We have programs that go to the source term with the fission product retention associated with nuclear plants. We are also improving our model for predicting releases—let's call them atmospheric releases. This model will provide useful service to State and local governments as they develop emergency preparedness plans. We are going to be looking at hydrogen behavior and containment, and looking at operator qualification and training.

The man-machine interface in terms of control room display systems is being evaluated, and we have done a comprehensive evaluation of containment sump performance and unresolved safety issues. And we are happy to report that based at least on preliminary results, we don't anticipate that there will be any issue associated with containment sump performance during accidents.

We are looking at qualification of hardened in containment instruments, seismic performance of various modern materials and plant designs, and finally at a very careful fire model analysis to see what might be the safety considerations associated with fire in nuclear plants.

These initiatives are intended to have immediate impact in terms of keeping nuclear reactors on line and avoiding unavailability. We feel that over the near term, reactor availability is very closely linked with oil consumption. When a nuclear plant is unavailable or a nuclear plant is delayed in coming on line, inevitably the vast bulk of that electrical generation has to be made up with oil-burning capacity. So we attach a very high priority to these near term issues associated with light water reactors.

In addition, though, we need to look at the long term. We need to look at what it is going to take to allow this country to have access to the levels of nuclear power that may be needed at the turn of the century. We need an improved, streamlined licensing process. We are looking at early site characterization as an important step in that direction, and then a variety of activities that I have lumped under what we call the one-stop licensing.

What we mean by one-stop licensing in the broadest sense is an ability to get, hopefully at the earliest stages of the nuclear project, all of the main issues surfaced so that a decision can be made, including necessary hearings and any intervention, before enormous capital investments have been made. And then, after a determination has been made that there is a need for nuclear power and that there is a good match between the site characteristics and the design that is being considered, the utility and the supplier will be allowed to go forward with expeditious construction and operation of that facility.

We feel that approach has the potential to save an enormous amount of time and money.

Mrs. BOUQUARD. What time duration do you think can realistically be achieved for carrying out the licensing process?

Dr. DILLON. We feel that it is certainly technically possible to carry out many of the same reviews and construction approaches that are currently taking, 14 to 15 years, in 6 or 7 years. That change will certainly make a tremendous difference in terms of potential utility investor decision on whether or not to go forward with the nuclear powerplant.

Mrs. **Bouquard**. Do you think it is necessary to have on site simulators for nuclear powerplants as a requirement?

Dr. **Dillon**. I think that many utilities will probably be having simulators, maybe not at every single site, but I think that the training of their personnel is emerging as a very major and demanding priority. And it is something that is getting a lot of attention now. We have programs which are targeted at that, and we are working closely with INPO to help them define what are the training requirements for their operators. And this will be an important part of planning for nuclear capacity in the future.

Mrs. **Bouquard**. Do you see more standardization resulting from a one-stop licensing procedure?

Dr. **Dillon**. Yes, I think that a great deal of standardization, in fact, has already occurred in the nuclear industry. And we have programs in modular construction that we feel will allow us to take credit for that standardization that has occurred.

The standardization and modular construction have benefits in terms of safety. It is easier to apply high levels of quality assurance when you are doing the same design or the same components over and over again. So we feel it is important not only to encourage this evolution which has been occurring naturally, but also to make sure that full credit for that is taken in terms of the licensing process and in terms of public confidence.

Mrs. **Bouquard**. Please go ahead.

# THREE MILE ISLAND ACTIVITIES

- CATALYTIC
  - LIMITED SCOPE
- R&D
  - NEW TECHNIQUES
  - GENERIC DATA
  - DATA STORAGE
- INFORMATION AND EXAMINATION
- COOPERATIVE
  - GPU
  - NRC
  - EPRI

VIEWGRAPH 9

Dr. DILLON. The next main element that I want to address is the Three Mile Island activities shown on viewgraph 9. And I want to make a few general points about the program, before I describe some of our technical activities.

I think it is important to note that the Government role is really considered to be catalytic. Our activities will be part of a much larger cleanup effort, and will certainly, in terms of any cash outlays, be a minority part—probably less than 10 percent of the total effort. The purpose of our program is R. & D. We want to gain new knowledge that's of value to the nuclear industry as a whole.

This includes new techniques that will be developed and generic data bases that will be made available to the entire nuclear industry. In fact, our base program which we have called information and examination has been underway. We will focus heavily on this aspect of archiving both material and data for present and future use.

In addition, we are proposing initiatives in two areas of resin vitrification and core access and removal. Those initiatives are contingent upon a satisfactory agreement among all the parties involved: GPU, the Pennsylvania Public Utility Commission, the Nuclear Regulatory Commission, and DOE.

Our base program, the one on information and examination, is operating under a memorandum of understanding among the Department of Energy, GPU, NRC, and the Electric Power Research Institute, and is working very well.

Let me turn now to the activities shown on viewgraph 10.

## THREE MILE ISLAND ACTIVITIES

- ELECTRICAL EQUIPMENT SURVIVABILITY
- RADIOACTIVITY AND ENVIRONMENT
- CORE EXAMINATION
- CORE REMOVAL
- RESIN VITRIFICATION

Viewgraph 10

Dr. Dillon. Particularly I want to emphasize the areas of new initiatives in vitrification. We propose a program wherein after the General Public Utilities has operated their submerged demineralizer system, that they will put the liners into shipping casks and ship them to a DOE contractor, where they will be stabilized in glass and encased. At that point we will be able to conduct general R. & D. on the stability of the package and the material, and during that process develop general techniques for what we would call typical nuclear waste.

These are the unexpected types of waste that might occur not only from an incident such as Three Mile Island, but perhaps from a variety of different sources. And this will put us in a very strong position to deal with these when they arise again from any other circumstance.

The other aspect of the program is an aggressive program on core access and removal. The first component of that would be to conduct localized decontamination to essentially clear a path to get early access to the reactor head. We need to then establish support services, certain kinds of plumbing and instrumentation, that will allow us to get access to that.

For example, the level of water in the reactor will have to be lowered. After that is achieved, we will penetrate the head through three control rod drive mechanisms and conduct an incore examination with TV cameras and other remote capabilities, that will allow us to develop a careful plan for the removal of the head and the plenum in the upper part of the reactor core.

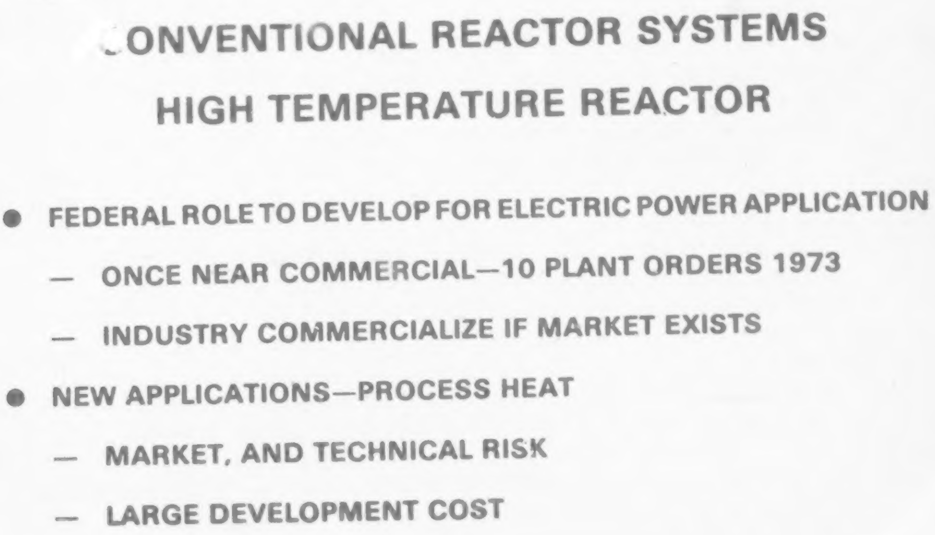
Then we will proceed systematically with removing the loose material from the reactor and packaging it and shipping it to DOE facilities for examination.

Now, the core and the material from the core is the information data that is of vital interest to us. It's specific and certainly unique input to the regulatory processes that I described earlier. We feel that the earlier that we can get that information, the better off we will be in terms of being able to apply it in different kinds of rulemakings and in different kinds of proposals and concepts for a streamlining of the licensing process.

So there is a time urgency associated with our R. & D. program from that point of view. Also from a technical point of view, the longer that material sits in the core, the more the effects of storage and standing will begin to mask the real information we are looking for, which is what happened to that core during the accident? So we will be losing information if time passes. And that is another reason why we are anxious to get early access to the core and get this information.

Finally, the nature and documentation of the removal of material from the core is going to be an integral part of the information base. And certainly the usefulness to us and the generalization of that information to light water reactor systems will determine how carefully we keep track of where the material came from.

These are the reasons why the Department is proposing an early aggressive program to get access to the core. Certainly the timetable that would be consistent with just cleaning up the reactor wouldn't meet the kinds of time scale objectives that we are talking about.



## CONVENTIONAL REACTOR SYSTEMS

## HIGH TEMPERATURE REACTOR

- FEDERAL ROLE TO DEVELOP FOR ELECTRIC POWER APPLICATION
  - ONCE NEAR COMMERCIAL—10 PLANT ORDERS 1973
  - INDUSTRY COMMERCIALIZE IF MARKET EXISTS
- NEW APPLICATIONS—PROCESS HEAT
  - MARKET, AND TECHNICAL RISK
  - LARGE DEVELOPMENT COST

Viewgraph 11

Viewgraph 11 concerns the high temperature reactor. Mr. Lujan had asked about this. The Federal role for developing electric power application of HTGR's had been questioned some years ago. It was felt that because this technology was once near commercial—in fact, the supplier once had 10 plant orders, which they then had to cancel—that we have always felt that it would be up to the industry to commercialize it if the market exists.

We have pursued the program in terms of its unique applications in the area of process heat, in particular. However, in reviewing those, we find that there are significant risks of a market and technical nature associated with these high temperature process heat applications.

In addition, there are very large developmental costs. In doing the review of the 1982 budget, the trade-off between these large costs and the serious risk associated with the market and the technical aspects of the program led to a decision to recommend termination of the high temperature reactor program.

## LOW ENRICHMENT FUELS FOR TEST REACTORS

- LOW POWER REACTORS
  - FULL CORE IN FORD REACTOR
  - PROTOTYPE ASSEMBLIES
- HIGH POWER REACTORS
  - POWDER FABRICATION
  - IRRADIATION TESTING
  - REACTOR PHYSICS
  - THERMAL HYDRAULICS

VIEWGRAPH 12

The final area I wish to discuss in the conventional reactors program is, as shown on viewgraph 12, the use of low enrichment fuels for test reactors. Our goal is to provide reasonably equivalent performance in research reactors, using uranium enrichments of less than 20 percent. Now, our program is really of a different nature in two different categories; low power reactors, research reactors of less than 5 megawatts, are by far the more dominant kind. There are 28 such reactors in the United States, and 112 in other countries. And we now have fuel materials which we feel could be tested, proved, and validated in actual reactors. There is going to be a full core test running a reactor in the University of Michigan that will allow us, I think, to convincingly demonstrate that you don't need to go to high enrichment in those reactors.

High power reactors are a little bit more difficult, a little bit more challenging task. There we have to develop new fuel materials. We are working on powder fabrication techniques and are doing some preliminary radiation testing in terms of very small samples. We are looking forward in the near future to developing test specimens for irradiation as reactor elements. We are doing calculations on the reactor physics and thermalhydrolics that we hope will allow us to develop fuels for these high powered reactors, greater than 5 megawatts, that will also allow them to operate at much lower enrichments.

## ACCOMPLISHMENTS

- DEMONSTRATED 29% INCREASED FUEL BURNUP
- DEVELOPED REMOTE EMERGENCY VALVE MONITORS
- DEVELOPED FIRE BARRIER MODEL
- ESTABLISHED COOPERATIVE EFFORT WITH INPO
- ESTABLISHED CITIZENS MONITORING PROGRAM AT TMI
- REMOVED INSTRUMENTATION FROM TMI REACTOR

VIEWGRAPH 13

Finally, I would like to turn to a status report of the conventional reactors program. Viewgraph 13 shows some of the accomplishments that we've achieved over the past year. I told you we were very encouraged about the high burnup fuel material and turning it over to the private sector. We completed some irradiations in the Oconee reactor, where we increased the burnup from 31 to 40 megawatt-days per ton. And as a result of those experiments, Duke Power, which is the utility that owns the Oconee reactor, has decided to order their reload fuels to these higher burnups. So we feel that the technology transfer process is underway.

The second accomplishment I wanted to speak to is remote valve monitoring. This is a capability using acoustic emission to monitor relief valves. This is the kind which stuck in TMI and eventually lead to the sequence of mistakes that lead to the accident. A monitor such as this, would give a positive indication of whether or not the valve was open or closed and, of course, would have prevented that kind of an accident. Based upon the results that we've achieved to date, many utilities have elected to install this type of monitor in their plants.

NRC has accepted this for use in the plants, so we feel here is another good example of where the technology transfer has been successful, and leaves us feeling that the working relationships we have with the industry are effective.

We have developed a fire barrier model with the National Bureau of Standards that's going to allow us to look in the reactors and see what are the most strategically sensitive parts of those reactors in terms of fire protection, and how can we model the barriers that exist in the plants, in terms of their resistance to fire spread.

The fourth area is the one I mentioned earlier, cooperation with INPO. There are three major tasks which are an important response to the Kemeny Commission Report. We're going to assess utility manpower and training requirements. We will do an analysis of job requirements that can be used by INPO to help guide utilities in the training of their personnel. We will develop a generic operating procedure and evaluation handbook that can be used by INPO and the cooperating utilities in the evaluation of the procedures that they use in their plants.

The fifth area is our citizens' monitoring program that we conducted at the Three Mile Island facility. I think this is an excellent example of how encouraging a well-informed and knowledgeable public increased the acceptance of even this very unfortunate aspect of nuclear power.

The Department, working through the State of Pennsylvania Department of Environmental Resources, worked with 50 citizens in 12 communities within a 5-mile radius of the damaged plant. These citizens had a capability to make radiation measurements which they used before, during and after the krypton venting. Because of these citizens and their independent verification of these radiation measurements, there was not that great a level of concern about the krypton venting after this had occurred.

The people that were involved came from every walk of life. We had expectant mothers. We had students, policemen, and others. So it was an excellent program and I think, again, it illustrates the difference it can make when you have a well-informed public in terms of their reaction to nuclear power.

The final area is, we have removed some instrumentation from the damaged Three Mile Island reactor. In fact, one piece of instrumentation was a radiation monitor that, although it operated continuously after the accident, it was giving erroneously low radiation measurements. We were able to determine that seepage of the containment spray into the device caused the malfunction. A very simple solution, of having the cables enter the device from the bottom instead of the top could have prevented the malfunction.

So this is an example of how we are using the information that we get out of the Three Mile Island plant to allow us to suggest improvements for future plants.

Well, that concludes my statement, Madam Chairman. I would be happy to answer any questions you might have.

[The prepared statement of Dr. Dillon follows:]

Statement of
Thomas A. Dillon
Deputy Assistant Secretary
for Nuclear Reactor Programs
Department of Energy
Before the
Committee on Science and Technology
Subcommittee on Energy Research and Production
March 19, 1981

## CONVENTIONAL REACTOR SYSTEMS

Madam Chairman and Members of the Subcommittee, I am pleased to appear before you to discuss the Department of Energy's Conventional Reactor Systems Program.

I am accompanied by Jerry D. Griffith, the Director of the Office of Light Water Reactors, and Franklin E. Coffman, the Director of the Office of Advanced Nuclear Systems and Projects. The major elements of our Conventional Reactor Systems Program are carried out under the direction of Messrs. Griffith and Coffman.

It is widely recognized that a healthy economy requires an expanded use of electricity generated by coal and nuclear power in order to reduce our dependence on expensive, unreliable supplies of foreign oil. This dependence has contributed to inflation and slowed our economy thereby reducing the demand for electricity. These effects have been compounded by problems that are inhibiting the expansion of nuclear power that is in our national interest.

Key obstacles to this expansion include:

1. A lengthy and complicated licensing process
2. Electric utility financial problems
3. Lack of public understanding and appreciation for both the benefits and risks of nuclear power
4. Uncertain Federal Government nuclear policy

Failure to adequately deal with these obstacles has had severe consequences. Since 1976, the Nation's utility industry has cancelled over 50 nuclear plants previously ordered, and fully completed plants are currently sitting idle awaiting approval from the Nuclear Regulatory Commission. There is presently a defacto moratorium on new construction permits, and no new orders are being forecast in the foreseeable future. The time required to produce new nuclear plants has more than doubled to where it now approaches 15 years. Industrial facilities are being shut down and millions of dollars worth of partially completed components from recently cancelled plants are being scrapped. The accident at Three Mile Island and the continuing delays being experienced in cleaning up the accident indicate a serious problem with our institutional arrangements to deal with nuclear accidents. Thus, the entire U.S. nuclear industrial base capable of meeting a 30 GWe per year growth is, instead, in jeopardy.

These problems have developed over many years and their solutions will not be quick nor easy, but we must begin to act now. The new Administration is committed to help get the nuclear industry back on track again. We are setting in motion the effort to regain our lead in nuclear technology and restore confidence in our commitment to rely on nuclear energy as a major contributor to our future energy supply. The programs that I will discuss with you this ~~morning~~ afternoon do begin to address some of these issues. The Department will continue to evaluate the effectiveness of these Conventional Reactor Programs in helping to restore the health of the nuclear industry. It may be necessary to modify the direction of some of these programs in the future in response to both the Administration's emerging nuclear energy policy, and in response to how effective they are in contributing to the solution of the real world problems of the nuclear industry.

The objective of the Conventional Reactor Systems program is to enhance the use of domestic nuclear energy resources.

The program is organized into five elements: Light Water Reactor Systems, Three Mile Island Activities, High Temperature Reactors, Advanced Reactor Systems, and Program Direction. The authorizing legislation, which is applicable to the Conventional Reactor Systems Program, is found in Sections 31 and 32 of The Atomic Energy Act of 1954 and in Public Law 96-567, "Nuclear Safety Research, Development, and Demonstration Act of 1980."

The total funding request for Conventional Reactor Systems in FY 1982 is $69.5 million in budget authority compared to $84 million in FY 1981. ① This request is broken down by program element as follows:

| | FY 1981 | FY 1982 |
|---|---|---|
| | (in millions) | |
| Conventional Reactor Systems: | | |
| Light Water Reactor Systems | $ 35.0 | $ 28.0 |
| Three Mile Island Activities | 6.5 | 37.0 |
| High Temperature Reactors | 40.0 | 0.0 |
| Advanced Reactor Systems | 1.0 | 3.0 |
| Program Direction | 1.5 | 1.5 |

I will now address each of those program elements in order.

## LIGHT WATER REACTOR SYSTEMS

The light water reactor systems program element involves the development and demonstration of technology to improve the utilization of uranium in LWR's, reduce occupational radiation exposures, improve plant productivity, and lower the probability and consequences of nuclear accidents.

### LWR URANIUM UTILIZATION

The activities directed at improving uranium utilization in LWR's to obtain better utilization of our uranium resources, reduction in the storage requirements for spent fuel, and better fuel cycle economics will be brought to an orderly conclusion in FY 1982. A 15 percent reduction in uranium requirements is targeted for 1988. The most straightforward near-term means for substantially improving uranium utilization toward meeting the 15 percent improvement goal is to develop higher burnup fuel for use in existing and future reactors.

The accomplishments of this subprogram have included demonstration of the capability of LWR fuel to achieve extended burnup. Fuel from each of the five U.S. fuel vendors, equivalent to eleven fuel assemblies, has been irradiated in five commercial light water reactors and has achieved burnups up to 40,000 megawatt-days per ton (MWd/t). An advanced high burnup fuel has been designed to achieve burnup of 50,000 MWd/t, and four assemblies have been fabricated for irradiation testing. This subprogram has also demonstrated, by test reactor irradiations, a pure zirconium-lined cladding that is resistant to pellet-cladding interaction (PCI) failures. Resolution of the PCI issue contributes significantly to improvement of fuel integrity, capacity factors, and load-following capability of LWR's. A large-scale demonstration has been designed to be conducted in a commercial light water reactor using 132 assemblies incorporating the PCI remedy cladding, and fabrication of these assemblies has begun. In the supporting research and development program, four international cooperative projects have investigated fission gas release in high burnup fuel and obtained other relevant data on selected separate high burnup effects.

The overall strategy for this subprogram has been to accomplish these uranium utilization improvements through multiple cost-shared projects with industry aimed at the development and in-plant verification of improved technology. Thus the Federal role and cost are minimized. This strategy enhances and accelerates the level of R&D while encouraging commercial demonstration and utilization of improved technologies. These efforts in the uranium utilization improvement area involve eleven electric utilities, all five nuclear fuel fabricators, two utility-supported organizations sponsoring technology development, and a large number of European and Japanese organizations. With the completion of the ongoing demonstrations these programs should provide for the accomplishment of a major part of the 15 percent utilization improvement goal for 1988. These demonstrations will begin to be brought to an orderly completion in 1982.

There are five high-burnup programs which will continue to generate fuel performance and design information for burnup increases over present designs. In the near term, these increases are about 10,000 MWd/t (megawatt days/metric ton) for pressurized water reactors (PWR's), and about 8,000 MWd/t for boiling water reactors (BWR's).

Technology development and verification projects in support of high burnup concerns such as pellet-clad interaction (PCI) and fission gas release will also be continued. These efforts include two major projects for verifying PCI remedies, involving Commonwealth Edison Company and Consumers Power Company as prime contractors. They also include several internationally-sponsored projects to obtain fission gas release data needed in technical support of high-burnup fuel design and to determine the PCI-related performance of current and improved fuel designs.

Additionally, the project directed at developing and verifying a method other than high burnup for improving uranium utilization will also be continued. In this project, the design and inplant demonstration of an axial blanket for PWR are being conducted, with Sacramento Municipal Utility District as the prime utility contractor.

## OCCUPATIONAL DOSE REDUCTION/PRODUCTIVITY IMPROVEMENT

The goals of this program are: 1) to support the Government policy of minimizing radiation exposure to nuclear power plant operating personnel, and 2) to increase the reliability and availability of nuclear power plants.

The specific objective of the radiation and dose reduction portion of this subprogram is to develop and demonstrate the technology, and the improved maintenance and operational practices that will reduce occupational radiation exposure to LWR plant personnel.

The accomplishments to date have included: the demonstration of the ability of remote acoustic emission monitors, to be used as a substitute for manual inspections in radiation fields, to indicate the position of emergency relief valves of the type that failed to open in TMI-2; completion of facility construction, material tests, and safety and environmental review by NRC staff in preparation for chemical decontamination of the Dresden-1 reactor.

The specific objective of the productivity improvement portion of this subprogram is to improve plant availability/capacity factor for existing plants as well as ways of shortening the siting, design, licensing, and construction times for new plants.

The major accomplishment to date has been the development of design standards to eliminate flow-induced-vibration failures in LWR components.

The requested budget level of $5,000,000 for the occupational dose reduction/productivity improvement subprogram will limit the FY 1982 activities to the completion of ongoing FY 1981 projects on 1) steam generator denting mitigation, and 2) remote surveillance and diagnostic techniques. It will permit initiation of one new project to develop and demonstrate the technology for dilute decontamination processes for LWR's.

## LWR SAFETY TECHNOLOGY

The LWR Safety Technology Program is directed at 1) developing technology that can be used by industry and the NRC to simplify the rules and methods used in nuclear plant design and operations, while maintaining a high level of safety; 2) maintaining and improving the performance of plant components and systems; and 3) improving plant operations and maintenance. This involves acquiring data and technology necessary to improve the performance of plant components and systems, to determine staffing and training requirements for nuclear facilities, and to provide improved tools for use by operators in running the plant.

Key activities expected in FY 1981 are as follows:

1) Initiation of planning for the baseline characterization of modern standardized LWR nuclear powerplants.

2) Initiation of efforts to transfer to industry Government-developed technology related to designing instrumentation for accidents.

3) Initiation of a task to upgrade a Government-developed radiation transport model to provide independent predictive capability for Federal, State, and local governments to utilize in emergency planning.

4) Completion of analytical efforts to develop a model for improved plant barriers against fire.

5) Investigation of feasibility of an approach to extend modularization technology for LWR's with potential safety and quality assurance advantages.

6) Test of containment sump operating characteristics to resolve a generic issue identified by NRC as significant to LWR safety.

7) Specific tasks to augment industry efforts directed to the improvement of LWR operator training and plant operations and maintenance.

8) Initiation of efforts to assist in the development of a National Data Base.

This subprogram would address the areas covered by Public Law 96-567 the Nuclear Safety Research, Development and Demonstration Act of 1980.

The following three areas will be emphasized:

1) Information display and operator training;
2) Developing data and analytical capabilities to improve emergency planning; and
3) Acquiring technical data and analytical approaches to provide resolution of licensing issues.

The work on control room information display is responsive to the lessons learned from the Three Mile Island accident and is concentrated in two general areas--1) a computer driven information console to be retrofitted to existing control rooms, and 2) the qualification of selected in-containment instrumentation to withstand seismic, radiation, and temperature conditions. Also, in response to the lessons learned as a result of the accident at Three Mile Island, the utility industry formed an Institute of Nuclear Power Operations (INPO). Last year the Department executed an agreement with the Institute through which we are supporting three tasks that will advance the technology of plant operations and training. First, we are conducting, in cooperation with INPO, an overall assessment of utility manpower and training requirements; second, we have contracted for an analysis of operator job requirements so that INPO can guide utility training; and third, we plan to develop an operating procedure evaluation handbook for INPO and the industry.

Data from TMI on retention of fission products during accidents are being evaluated so that this information can be factored into to the standards and criteria used by NRC and industry when analyzing nuclear plant accidents and in formulating subsequent emergency plans. In addition, specific improvements are being made to the atmospheric dispersal computer model used at TMI to predict radiation transport. This model can be used by Federal, State, and local government agencies to provide independent analyses for emergency planning.

Several continuing developments have been pursued to aid in nuclear plant performance analysis, including application of the Safety Level Concept. In addition, the state of the art of LWR plants will be characterized, which will provide a baseline for safety improvements and trade-off decisions.

As required by Public Law 96-567, the following three specific studies called for by the legislation will be completed in FY 1982: 1) a comprehensive management plan, 2) a study of the need and feasibility of a National Reactor Engineering Simulator, and 3) a study of the sufficiency of U.S. efforts to provide specially trained operators for nuclear plants.

In addition to these parts of the program that specifically address the requirements of Public Law 96-567, the following work will also be continued:

1) The modularization approach to simplifying LWR plants and, thus, their safety and economics will be further explored.

2) Work will continue to test a LWR containment building sump model to resolve a generic safety issue.

3) A model that should improve the fire safety of plant barriers will continue to be tested.

4) Efforts will continue to improve LWR plant materials and structures to include resistance to seismic phenomena.

5) Efforts will be continued to provide support for the development of an LWR National Data Base.

6) Support will continue for the Nuclear Safety Information Center.

## THREE MILE ISLAND ACTIVITIES

The overall goal of the DOE's Three Mile Island activities has been to develop and improve measures for enhancing safety and reliability of nuclear powerplants and to improve the capability to decontaminate civilian nuclear powerplants. To accomplish this goal, we are pursuing a program of carefully examining and evaluating the TMI-2 accident and the response of the nuclear powerplant components, systems, and materials to accidents. In addition, the Administration is proposing a new initiative in FY 1982, to help resolve technical issues that currently impede the cleanup of the plant.

DOE developed our present TMI information and examination program based on a Memorandum of Understanding signed by the Department of Energy, Nuclear Regulatory Commission, Electric Power Research Institute, and the General Public Utilities (GPU). GPU's efforts are directed primarily at plant cleanup and recovery. DOE's strategy has been to develop a program work scope that will obtain information that would not be obtained from GPU's efforts, that would not delay the GPU schedule, and that would be of generic value to the entire nuclear electric utility and supply industry. This will improve the understanding of the TMI accident and the response of nuclear powerplant components, systems, and materials to accidents. This program began in FY 1980. A Technical Integration Office has been established at TMI to manage the Government's activities under DOE's direction with EG&G Idaho as lead contractor. The technical information being obtained is being provided to the nuclear industry and the NRC through means of reports and seminars.

DOE is presently funding four major tasks: instrumentation and electrical equipment survivability; radioactivity and environment; technical integration of data and storage of archive specimens; and reactor core and fuel examination. EPRI has assumed responsibility for mechanical and structural component reliability; pressure boundary recharacterization, and decontamination and dose reduction associated with the primary coolant system.

The accomplishments of this program to date include:

1) A citizen's monitoring program was sponsored by DOE in cooperation with the State of Pennsylvania to monitor the levels of radioactivity that might be present in their communities prior to, during, and subsequent to venting of krypton from TMI-2. The citizens were able to compare their results with official results thereby alleviating some of their concerns.

2) At the beginning of FY 1981, a joint computerized data bank was established with EPRI, and a seminar was held with representatives of foreign countries to describe the TMI program.

3) TMI plant instruments have been tested in-situ and offsite. Offsite examination of one instrument has been completed by Sandia Laboratory and additional off-site instrument examinations are planned in FY 1981.

4) A closed circuit TV camera system has been installed in the containment building during a recent manned entry for use in documenting recovery operations.

5) DOE will investigate the conservatism of the iodine source term used in site evaluation using data obtained at TMI that characterize the transport and deposition of radioactivity in the plant.

6) Resin liners used to clean the contaminated water in the TMI-2 auxiliary building will be examined at Battelle Columbus Laboratory, in order to determine how to store and dispose of these resins.

7) The development of tools and techniques for assessing core damage with the reactor head in place continued. Fabrication of hardware is underway and testing will be completed by the end of the fiscal year. A preliminary design of canisters for canning damaged core components was also recently completed.

The $10 million of the funding request to be applied to this program in FY 1982 will continue the data gathering activities previously described, focusing on additional examination of electrical equipment, radionuclide analysis of samples removed from containment, and developing fuel and core examination techniques. It will continue to be conducted in cooperation with NRC, EPRI, and GPU in accordance with our joint Memorandum of Understanding, dated March 26, 1980.

In addition to the preceding efforts that comprise the current TMI program, and in response to requests from the House Appropriations Committee last year for DOE to assist GPU and NRC in resolving problems holding up the cleanup operation, DOE is proposing to broaden its program to include efforts to resolve technical issues that currently impede the cleanup of the plant. The expanded effort will require a funding level of $27.0 million in FY 1982. The use of these funds is contingent upon an agreement between the Department, General Public Utilities, the Pennsylvania Public Utilities Commission and the U.S. Nuclear Regulatory Commission that will limit the Federal role to necessary research activities in support of private cleanup efforts.

This would permit DOE to plan and implement a comprehensive core access, examination, removal, and encapsulation program, and plan a high confidence zeolite resin vitrification and testing program. Assuming prompt action by NRC to approve GPU's request to begin containment sump water cleanup, and prompt action by the Public Service Commissions to permit adequate funds for the other cleanup operations, both of these programs could be initiated in FY 1982. The FY 1982 core removal program would include necessary local decontamination of the containment building, refurbishment and provision of necessary auxiliary systems and equipment, and initiation of an early core damage assessment. Removal of the reactor vessel head would be planned at the end of the fiscal year.

There are several benefits that will be realized from the pursuit of this program. The costs of cleaning up the water and defueling the core will be substantially lower if these jobs are undertaken expeditiously and, therefore, the financial impact on all parties concerned will be substantially reduced. In addition, opportunities for further deterioration of equipment with possible public and occupational health consequences will be reduced. Furthermore, an expeditious cleanup will help alleviate the concerns of the utility industry that have arisen because of the continuing delays being experienced in cleaning up TMI.

## HIGH TEMPERATURE REACTOR

The High Temperature Reactor Program has been recently supported because of its potential to serve several unique market areas that require very high temperature operations. These include special efficient electrical power and process heat energy production capabilities adapted for use in concentrated industrial areas and water-short regions. The use of these systems, however, is subject to very long and costly development and commercialization programs. The need for this concept relative to its projected development cost and risk is sufficiently uncertain that a relatively low priority has been assigned to this program. Therefore, the decision has been made to withdraw Federal support for this program in FY 1981 and a recission of $22.2 million has been requested.

## ADVANCED REACTOR SYSTEMS

The objective of the Reduced Enrichment Research Test Reactor (RERTR) Program is to develop and demonstrate technology for fabricating low-enrichment uranium (LEU) fuels for research and test reactors. This will facilitate significant reductions in the need for United States supplied inventories of high enriched uranium abroad and the related proliferation risks.

Fabrication and delivery of a full core of LEU-fuel for the Ford Nuclear Reactor will be completed during FY 1981 and early FY 1982. Prototype reduced-enriched uranium (REU) fuel assemblies will be delivered to the Oak Ridge Research Reactor and the High Flux Reactor at Petten in FY 1981 for irradiation-performance verifications during FY's 1981-82-83. First generation miniplates of high U-density aluminide, oxide, and silicide fuels were irradiated in the ORR to about 50 percent burnup. Technical assistance was provided in about one dozen joint studies on conversions of foreign reactors to LEU-fuel. About 20 evaluations of HEU-export requests were completed for guidance to the Administration. At least two dozen visitors from developing nations will receive training at ANL, some under IAEA Fellowship, in assessing the convertibility of their research reactor(s) to REU-fuels.

The funding request of $3 million for FY 1982 will be used as follows:

1) The performance of a current technology LEU-fuel will be characterized and verified in the Ford Nuclear Reactor and prototype assemblies of REU-fuels with very high uranium densities will be demonstrated in the Oak Ridge Research reactor.

2) Development of fabrication technology for a much higher U-density silicide fuel, establishment of commercial production capabilities during fabrication of such fuel for an appropriate reactor, and performance-verification of very high U-density LEU-fuel in a selected reactor will be accomplished.

3) Reactor physics and thermal-hydraulic characterization of typical full core applications of reference LEU-fuels will document the basic operating and safety data needed by NRC for future conversions of research reactors to LEU-fuel lattices.

Participation by numerous foreign reactor operators and fuel fabricators in RERTR Program activities, and the creation of complementary RD&D programs in Japan, France, Germany, and Argentina, are indicative of the international acceptance of the REU-fuel concepts.

Since commercial fuel fabricators have shared in the development of the high U-density fuels technology, it is more likely that it will become a commercially accepted technology.

Mrs. **Bouquard**. That was a very detailed and very fine statement, and I certainly do applaud you for your preparation and insight and for the great work that this certainly does represent.

I would like to go back to TMI to start our review.

Dr. Dillon, of course, as you know, this Committee has the sole responsibility of research, development, and demonstration, and I was very interested in your plans for removing and examining the TMI core and your plans for removing the vitrified resins. But for each activity in this program, I certainly need you to identify whether or not the activity is directly an R. & D. activity and, if so, explain how it does fit in this category, and for each activity provide the funding for operating and capital to support this effort.

And I think it might be proper and be in better form, if you would present this information to us in writing, if you could, by late Monday afternoon as we begin our markup.

Dr. **Dillon**. Certainly.

[Information to be furnished follows:]

## DEPARTMENT OF ENERGY

## THREE MILE ISLAND R & D

The Department's Research and Development program to inspect the damaged Three Mile Island reactor core, and to conduct research on vitrification of zeolite ion exchange media, are all research and development activities. The purpose of these R&D programs is to gather knowledge of value to the nuclear utility industry and the regulatory bodies. The specific activities to be conducted, in addition to the $10 million base program, are summarized below:

| | FY 82 B/A - Millions of Dollars | | |
|---|---|---|---|
| | Operating | Equipment | Total |
| 1. Reactor Core | | | |
| a. Early Core Damage Examination | 6.0 | 2.5 | 8.5 |
| b. Head and Plenum Inspection | 0.3 | 0.2 | 0.5 |
| c. Core and Debris Removal/Inspection | 11.2 | 0.3 | 11.5 |
| Subtotal | 17.5 | 3.0 | 20.5 |
| 2. Zeolite Vitrification | | | |
| a. Process Development/Scale-up | 1.5 | 0 | 1.5 |
| b. Equipping Hot Cell for Vitrification Tests | 1.0 | 4.0 | 5.0 |
| Subtotal | 2.5 | 4.0 | 6.5 |
| Total | 20.0 | 7.0 | 27.0 |

### REACTOR CORE

The data to be obtained from the reactor core R&D program will be invaluable in assessing and developing improved analytical tools to analyze severe accidents, and to evaluate improvements in reactor design and operating methods. It will have substantial relevance to new regulations and rulemakings planned by the NRC in the very near future.

The important R&D information to be obtained includes:

- The Early Core Damage Examination will gain early understanding of the condition of fuel and structural integrity of the equipment located above the core, including the plenum and control rod drive structures.

- The Head and Plenum Inspection will obtain more detailed understanding of the performance of the control rod drive structures and the upper core support structures, as well as data on the behavior of the reactor vessel head and closure mechanism.

- Core and Debris Removal and Inspection will yield extensive knowledge concerning the behavior of fuel under abnormal temperature and pressure conditions.

ZEOLITE VITRIFICATION

The zeolite vitrification R&D program is expected to contribute substantially to the technology and processing and disposing of unique waste forms resulting from commercial nuclear plant abnormal operations and accidents.

- Zeolite Vitrification Process Development will obtain data of off-gassing, cesium retention, process parameters, and product stability for use in vitrifying zeolites.

- The Hot Cell to be Equipped for Vitrification Tests will be used to conduct vitrification experiments on highly loaded zeolite liners, including in-batch variations, batch-to-batch variations and confidence and characterization testing of vitrified product.

to a much larger number of lower loaded liners.) Because of their higher radioactivity loading, the highly loaded liners must be properly immobilized prior to disposal. Bench scale tests have been conducted at DOE laboratories which indicate that a vitrification process is feasible and would result in the required immobilization. The Department's program is to take this laboratory scale work and scale it up to a full size process. Testing will include measurement of the variability expected among zeolite liners, from both a chemical and radionuclide loading standpoint, and "confidence" type testing on the vitrified products. In addition to gaining information on generic process (e.g., methods of control of off-gassing), the program will also gain information on the stability of resulting products that will be invaluable in planning, conducting, and regulating future waste disposal activities for commercial nuclear powerplants.

## III. Specific Activities to be Conducted in FY 1982 (Reactor R&D)

There are three basic activities planned as part of the early reactor core access and inspection program. These are (1) Early Core Damage Examination (Pre-Head Lift), (2) Head and Plenum Inspection, and (3) Core and Debris Removal and Inspection. The cost of conducting these programs depends to a significant extent on just how badly damaged the fuel really is. Estimates vary widely. Based on a realistic assessment of core damage, and no delays due to regulatory actions, we estimate the first activity will be completed in FY 1982 and preparations for the second two activities will be well advanced. Of the $20.5 million needed in FY 1982, about $8.5 million is for the Early Core Damage Examination (Pre-Head Lift), about $0.5 million for the Head and Plenum Inspection, and about $11.5 million to prepare for the Core and Debris Removal and Inspection activities. Of this $20.5 million, about $3.0 million will be required for capital equipment; and about $17.5 million for operating funds.

### A. Early Core Damage Examination (Pre-Head Lift)

The main purpose of the Early Core Damage Examination is to obtain an in-depth and undisturbed view of the damaged TMI-2 core prior to alterations to the core configuration which will occur during cleanup operations. TMI-2 can be considered an important reactor safety experiment and may yield many important answers with regard to research and development studies of damaged fuel performance.

The examination will provide: an understanding of the specific condition of the fuel and structural integrity of the equipment located above the core including the plenum and control rod drive mechanisms; data which will benchmark analytical studies of degraded core cooling; and data that will enable better R&D planning in the area of damaged fuel behavior.

## Description of Activities to be Conducted by DOE with Expanded TMI R&D Program

### I. Introduction

The Department's proposal to expand its TMI research and development program in FY 1982 is based on the initiation of two R&D programs: a program to gain early access to the TMI reactor core and to inspect it at TMI to acquire important generic safety data, and a program to conduct research and development on vitrification of the zeolite ion exchange media to be used in decontaminating the reactor containment building sump water. The conduct of these programs is expected to take two to three years. Of the $27 million requested in FY 1982, we expect to spend about $20.5 million on the early core access R&D program, and about $6.5 million on the zeolite vitrification R&D program. The specific activities to be conducted in each program, and the generic research information desired, are discussed in the following paragraphs. As with any research program, we expect there will be additional data and information obtained during the course of these activities which cannot be predicted ahead of time and which may provide significant contributions to our understanding of reactor performance and safety as well as radioactive waste disposal processes and products.

### II. Basic Objective of Expanded TMI R&D Program

#### A. Reactor Core

The examination of the TMI-2 reactor, core and core components will provide data that is required for evaluating present licensing criteria; developing future licensing criteria; assessing and developing computer models used to analyze the course and consequences of severe accidents (these models will improve risk assessment and accident consequences analyses and will be used to evaluate reactor design change recommendations); and reactor operation and maintenance. This includes assessing and developing improvements in items such as: indications of reactor status, equipment testing procedures, decontamination procedures and techniques for recovery from accidents. Much of this information would be considered in proposed NRC rulemakings; especially those related to degraded cores, establishment of safety goals, and control room designs. The schedule for these rulemakings require that this program be completed as soon as possible.

#### B. Zeolite Vitrification

The Zeolite Vitrification R&D Program is expected to contribute substantially to the technology for processing and disposing of unique waste forms resulting from commercial nuclear plant abnormal operations and accidents. A small number of highly loaded liners (up to 60,000 curies per liner) are expected to be produced during operation by GPU of their submerged demineralizer system. (This is in addition

Specifically, the R&D questions DOE plans to address in this activity, and the follow-on core/debris removal and inspection activity include:

- What is the extent of damage to critical equipment in-core and in-containment resulting from extreme pressure and temperature transients?
- How much fission product activity was released?
- Degree of eutectic formation and/or fuel melting?
- Degree of metal-water reaction?
- General core configuration and location of fuel debris?

To begin to obtain this information in FY 1982, DOE will sponsor those activities necessary to install remote viewing equipment through the reactor vessel head, and perform an inspection while the closure head is still in place. In order to protect the workers performing this examination, a limited amount of local decontamination and local shielding will be provided. The extent and amount of decontamination will be limited to that necessary for worker protection and will not include work ultimately required by GPU to cleanup the containment surfaces. For example, temporary shielding will be provided around the containment air coolers on the 347 foot elevation to protect workers transporting equipment to the reactor area; ultimately these coolers will have to be completely removed by GPU for plant cleanup. Additional activities necessary to protect and support the workers during this early core damage inspection include: special provisions to control the water level in the reactor vessel during the inspection, provision of safe lifting devices for handling the special tooling and reactor components, installation of special instruments to monitor core neutronics during the inspection, and provision of special monitoring and cleaning areas to protect the workers before, during, and after their containment entries to conduct the core examination.

### B. Head and Plenum Removal and Inspection

The purpose of this activity is to obtain data and information on the performance and behavior of the reactor vessel head, control rod drive mechanisms, and upper core support structures, during the accident.

Ascertaining the physical and metallurgical condition of these reactor components will provide insight into the actual temperature and pressure conditions which existed on March 29, 1979, and will provide a basis for determining the need for and nature of any improvements needed in future designs of these components. Since GPU would not conduct these inspections in order to clean up TMI-2, this activity has been included in DOE's proposed R&D program. Specific tasks included in this activity are: measurement of the loads required to uncouple the control rod drive mechanisms; and methodically dismantling the control rod mechanisms to determine the extent and distribution of damage; unbolting, removing and examining the reactor vessel head to determine its condition and likely performance during the accident; and inspections of the upper plenum parts which were exposed to some of the highest temperatures during the early hours of the accident. This activity includes the development of special tooling needed to perform the inspections including contingency tooling that might be required in the event of excessive distortion in the mating components. After inspection, the reactor components will be set down in designated spaces within the containment; cleanup and/or disposal of these components is NOT included in the R&D program and will be conducted by GPU in the course of their own cleanup activities. The FY 1982 tasks for this activity will include the control rod drive mechanism inspections and developing the inspection and other tooling necessary for dismantling the components in FY 1983. Actual inspection of the closure head and plenum will not occur until FY 1983.

### C. Core and Debris Removal/Inspection

Extensive knowledge concerning the behavior of fuel under abnormal conditions is to be obtained via a detailed and methodical examination of the reactor core itself. The examination will include visual as well as dimensional inspections, first of the entire core, and later of each piece of fuel as it is removed. Activities in FY 1982 will deal mainly with developing and testing the special tooling that will be needed to conduct this examination in FY 1983. The tooling will include restoration of the refueling bridge as needed to perform the core inspections, tools to break apart and remove any "crust" that has formed at the top of the core, tools to inspect and measure damaged fuel pieces, and to remove them, canisters to receive the damaged fuel, racks to store them in the fuel handling canal for later inspection and/or disposal, and equipment to minimize contamination spread in the fuel canal during inspection. With the exception of off-site examination of selected pieces of the damaged fuel in hot-cell, the DOE R&D program does not include provision for shipment and disposal of the bulk of the damaged fuel.

## IV. Specific Activities to be Conducted in FY 1982 (Zeolite Vitrification R&D)

Zeolite resins, loaded with high levels of radioactivity, have never been vitrified on an engineering scale. Resins with comparable levels of activity arise occasionally in the course of defense activities, but are handled within the confines of canyon buildings.

Similar resins, possibly also loaded with transuranic elements, could arise at commercial reactor sites under abnormal but not unusual conditions. The technology for their management is therefore of importance even beyond the TMI situation, and is most convincingly demonstrated with actual accident wastes. Variations in zeolite loading, glass composition, waste loading in the glass, and other process parameters require that many liners be processed ("confidence testing").

Three activities are planned in the zeolite vitrification R&D program: (1) Process development and scale-up; (2) equipping an existing hot cell with handling, vitrification and environmental control equipment; and (3) the shipping, vitrification and detailed examination of vitrified product from a small number of zeolite liners. Only the first two activities will be conducted in FY 1982; the latter activity is planned for FY 1983 and FY 1984. The R&D information to be gained from the process development, and then the confidence testing at full scale, will be important elements in future decisions on the planning, conducting and regulating disposal of wastes from commercial nuclear plants.

A. Process Development and Scale-Up

In Fiscal Year 1982, approximately $1-1/2 million in operating funds will be required for initial process development and the vitrification of a full-scale inert liner, as well as the vitrification of two loaded liners at the Pacific Northwest Laboratories located on the Hanford site. Data on off-gassing, cesium retention, proper frit ingredients, product stability, etc., will provide important technology of generic use in treating other abnormal wastes, and in preparing for the "confidence" testing and process variance evaluation in FY 1983.

B. Equipping Hot Cell from Vitrification Confidence & Batch Variation Testing

During FY 1982, approximately $4 million of capital equipment funds and $1 million of operating funds will be required for design activities, equipping hot cells and preparing a facility for R&D associated with the vitrification of zeolite liners. This facility will be capable of evaluating the TMI high loaded liners for in-batch variations, batch-to-batch variations and confidence and characterization testing of the vitrified product.

Mrs. BOUQUARD. Another thing I was very concerned about, doesn't NRC want the TMI R. & D. data as well?

Dr. DILLON. Well, I'm certain that NRC will be very interested in the data that we are acquiring. In fact, the data that we have acquired on fission product retention is already being used by the NRC, and they are analyzing it to see what it means in terms of some of the assumptions that are made, and the licensing of nuclear reactors.

There is a feeling that we have used overconservative assumptions on iodine release. The amount of iodine that was released from the damaged Three Mile Island was very much less than what had been predicted, based upon the models that are used.

So the answer to your question, Madam Chairman, is yes, we do expect the NRC to be interested, but certainly, the nuclear industry and the utilities are also extremely interested, in terms of what it might mean.

Mrs. BOUQUARD. My final question: Will NRC help pay some of the R. & D. cost on this?

Dr. DILLON. Well, we have proposed the program that we described, and we will now be contacting the NRC to get an agreement in terms of their willingness to allow us to proceed with these R. & D. activities at the Three Mile Island plant without undue delays associated with licensing decisions and regulatory decision. We haven't discussed with them their funding for Three Mile Island related activities, but I would ask Jerry Griffith if he knows how much the NRC budget is for Three Mile Island.

Mr. **Griffith**. I think the decision was made, when the information and examination program was set up, that DOE would conduct the program and would fund the program, and that it would be a joint effort, in which we participated with NRC. But thus far, the funding has all come from DOE.

Mrs. **Bouquard**. As you know, we are also operating under a very constrained budget, and we certainly want to make sure that our part and our participation is evolving around the R. & D. aspects of the investigation, so we will need this information by next Monday afternoon.

I was rather concerned about the description of the HTGR program. I was wondering why the light-water breeder reactor has a higher priority than HTGR.

Mr. **Gates**. Let me try to answer that, Madam Chairman. I think it is a complex question. When we set our goals for the fiscal year 1982 conventional reactor programs, there were a few things that we felt were musts. One we felt we had to reestablish in the light-water reactor industry, a high level of confidence. We felt we had to establish an equally high level of confidence in the American public and amongst our international allies, in order to bring our program into balance and focus and to do those things that I just mentioned. We wanted to do several things. We wanted to expedite the licensing process and establish a better-defined, if you will, regulatory program. We wanted to close the light-water reactor fuel cycle. We wanted to give emphasis to the light-water reactor program. We wanted to clear up TMI, as we have just indicated, and we wanted to get some waste in the ground as rapidly as we could.

Now they were the main avenues of our concern. We did want to fund also the high-temperature gas reactor, but in the final analysis, it was determined that the contribution of that program to meeting these goals and objectives that I just enumerated were somewhat peripheral to the objectives on which we decided to put the money, and in the negotiations back and forth, within the constrained budget, something had to give. It was the HTGR that we decided to give on.

Mrs. **Bouquard**. I still don't understand why the light-water breeder reactor has higher priority than the HTGR. Is there any industry participation or involvement or interest in this program?

Mr. **Gates**. In the HTGR?

Mrs. **Bouquard**. No, in the light-water breeder?

Mr. **Gates**. I'm not too articulate, Madam Chairman, on the light-water breeder reactor. It is a program that, as you know, and as you heard the other day, has been underway for a great number of years, and it is fairly well along the road toward completion.

To give up on that at the present time would mean, I think, the loss of what has already been gained and potentially might be gained in the few years remaining. The HTGR is not quite in that attitude yet, still being a more risky and longer range venture.

Mrs. **Bouquard**. How far along is it to reach the demo stage, Mr. Gates? The high-temperature gas reactor. What remains to be done before a demonstration could be planned?

Dr. **Dillon**. The demo that I think you might be thinking about would be an actual electrical generating HTGR that the utilities have been discussing. Their feelings are that that plant, a lead plant, could proceed with a schedule that would not be too much different than the schedule for the light-water reactor. However, that itself is quite a lead period of time. Right now, as I said earlier, we're talking about 15 years. There would be substantial first-of-a-kind costs associated with a lead plant of that kind, and that I think is the part that has made it difficult for the utilities to pull together the private venture capital that would be needed to finance that kind of a demonstration facility.

Mrs. BOUQUARD. The reason I was asking is, the utilities appeared before the subcommittee, as you know, and testified that they, indeed, would like to participate in the program. They were, indeed, willing to do their part in support of the program. I have yet to hear about any utility participation being offered for the light-waterbreeder program.

This is my concern. Are we in reality working on capital-intensive technology that will be transferred to the utilities in this decision?

Dr. DILLON. Well, the utility group, I think, has expressed the willingness to pay roughly the equivalent cost that would be associated with a light-water reactor and that all first-of-a-kind costs they would like to have borne by the Government. And those first-of-a-kind costs, particularly for the licensing that would have to be done, would be quite significant.

In addition, we would expect substantial costs associated with the fuel cycle. There doesn't, at this time, currently exist a fuel cycle for the HTGR, and that would be an important part of the demonstration of an HTGR system.

Mrs. BOUQUARD. HTGR is a long-term and high-risk technology, and yet it does not fall within OMB's guidelines to be funded; is that correct?

Mr. GATES. That is correct.

Mrs. BOUQUARD. Mr. Forsythe?

Mr. FORSYTHE. Thank you, Madam Chairman.

I would like to, again, go to Three Mile Island and, as I understand it, the $37 million allocated here is really totally R. & D. and doesn't really involve any funding toward the basic cleanup problems that are concerned.

Dr. DILLON. With one very small exception, that in order to gain early access to the core, to do the kinds of planning we need, we would have to do some very limited, very localized cleanup. That is a very small part of the cleanup job that has to be done, and its only purpose is to get early access to the core, so we can get the equipment and the personnel there.

Mr. FORSYTHE. And so close to $1 billion will be needed just to clear that mess up. Nothing will get replaced, but just clean it up, will cost in the area of $1 billion; is that correct?

Dr. DILLON. Yes, sir, that is their estimate now.

Mr. FORSYTHE. There is no other Federal funding beyond the R. & D. and the essential cleanup involved that you just described?

Dr. DILLON. No. In fact, that is a very important component of our proposal. The Administration is just as sensitive as this Committee that we have a very tightly circumscribed role, an R. & D. role, and that we not go any further. The activities that will allow us to get the information that is in the core are the only activities we will be engaged in. In addition, we will conduct activities related with vitrification of the resins resulting from the SDS systems.

Mr. FORSYTHE. It so happens that I have a small part in my district that has a GPU utility, so it does get a little bit interesting to me, to say the least. Essentially, if you look at these two pie charts you had, you really transferred that high temperature $40 million to TMI research; is that correct?

Dr. DILLON. Well, the pie charts were a little bit misleading, in the sense that there was also a net overall reduction. The Three Mile Island activities would have been at about $10 million, if it hadn't been for the initiative. So the initiatives are an additional $27 million, and that doesn't quite offset the $40 million reduction associated with the HTGR.

Mr. FORSYTHE. You had to find a way to get something that you had to have now, and if you didn't, you weren't going to be able to get the research as a result of the TMI situation?

Dr. DILLON. I think the tradeoffs were made in a larger sphere of consideration. In other words, it was a zero sum gain within conventional reactor programs, but the decision on the HTGR was made in a much broader tradeoff against other programs.

Mr. FORSYTHE. Is it a fact that the utility interest really didn't come alive until they figured that they were going over the cliff? I've had utilities in my office saying how much they want to have a lead plant, and all this kind of thing, but I haven't heard of this, and I have been on this Committee and this particular Subcommittee since it was formed in the last Congress, but I hadn't heard this from the utilities.

Dr. DILLON. One of the reasons why the Government has had a continuing interest in the past in the HTGR is this very strong utility interest. It is not that new. The Gas-Cooled Reactor Associates is really the latest in a sequence of utility entities that are enthusiastic and sponsor the HTGR concept.

That underlying utility interest has been one of the strongest aspects of the program. It's definitely true, though, that lately their interest has been piqued by the prospects of the program being terminated.

Mr. FORSYTHE. Do you have any estimate of what that first-time cost would be, what we're talking about or what they really are asking to keep that alive and make it go; what that first-time cost would be for the Government?

Dr. DILLON. It is very difficult to estimate what the cost would be, because of the uncertainties associated with the timing of the project, and some of the other things that might be encountered.

But we are talking about an amount of money just for the plant itself that would definitely be on the order of $1 billion, and it is a large amount of money. I would really hesitate to try to get any more precise, because one would really have to talk very specifically about when one would start such a plant and when one would finish it, and really, what some of the detailed design aspects of the plant would be.

Mr. FORSYTHE. It would take more computer work to get to even the point where you would have some confidence in what you're talking about.

Dr. DILLON. Yes, sir.

Mr. FORSYTHE. This concern in regaining public confidence in nuclear energy is needed, because in my view it is just something that we need so much—because I have viewed our conventional nuclear program as kind of the midterm situation, and I still don't see anything out there that is going to pick up for long term, until we see fusion, and that seems to be moving almost as fast as we can.

So thank you. Thank you very much.

Mrs. BOUQUARD. Thank you, Mr. Forsythe. I think that most of you on the panel know that really the focal point of my activities as a Member of Congress in the past 4 years is to see that we retain the nuclear energy option. I think it is very vital to our survival as a great and a free country.

I am very committed to this cause and I am hoping that we can see some decent public information on nuclear fission to come out of the Department of Energy.

Along the same line, in our base program of the $10 million for TMI, I am hoping that the information can be generated to the public that the real tragedy of Three Mile Island was indeed the negative impression that was left not only on the United States, but the entire world as well; and that there are things that did not happen at Three Mile Island. In a positive approach, that could certainly be presented to the people, because I think that this is one of the main ways that we can reestablish the confidence of the American people in our one source of energy that can really carry us through into the next century. And I hope that we will direct our activities along this line.

Mr. GATES. We share that view, and we accept the challenge.

Mrs. BOUQUARD. I certainly hope that you all are. I certainly look forward to working with you in this direction.

In addition to, of course, the $10 million in the base program at TMI, what happens if we don't fund $27 million for the initiatives in fiscal year 1982, the additional $27 million?

Dr. DILLON. Well, I think we will lose substantial opportunity in terms of gaining information about the reactor core—what happened there—because the time scale that the utility will want to proceed on will be the most economical to get on with their business, which is cleaning up the reactor.

And their priorities associated with doing that in the cheapest, most economically possible way won't be consistent with what is needed to get the benefit, the R. & D. benefit, and the information we want out of the core.

We will certainly get some information under that scenario. It will come much later, probably years after certain regulatory rulemaking procedures have closed, but we will still get some information—less, and later, and I think that is going to be a major problem.

In addition, I think there will be a similar missed opportunity with regard to the resins. But there, too, we would have an opportunity to take an early treatment of this material and show that we know how to handle it, and that we know what happens after that kind of atypical nuclear waste is treated and solidified in this way.

Mr. Gates. I think there is another issue here. I agree with what Tom has said, but I think the other issue relates to your comment just a moment ago to enhancing within the American public confidence in the nuclear option.

Certainly getting the TMI problem solved is a giant step to building in the American public the confidence that we wish them to have. The contribution of the Federal Government over the period of 3 years, that's something like $27 million a year in the R. & D. program of Three Mile Island, is viewed by us not only for its value per se in the R. & D. area, but also of value in moving toward cleaning up Three Mile Island by the utilities, the NRC and the State of Pennsylvania.

And it is kind of, if you will, seed money. We feel that by showing the Federal Government's interest we will be able to move the other people off dead center that they've been on so long. And in doing that, we will start to reach this objective of rebuilding the confidence of the American public in the nuclear option.

Mrs. Bouquard. Thank you very much, Mr. Gates, for appearing at our hearing today, as well as Mr. Griffith. Dr. Dillon, I think you have another topic for us this afternoon, "Advanced Isotope Separation," and you may proceed. And your testimony will be made a part of the record.

Dr. Dillon. Thank you, Madam Chairman and members of the Subcommittee. I am pleased to continue with a discussion of the Department of Energy's advanced isotope separation program.

## ADVANCED ISOTOPE SEPARATION PROGRAM

- PROMOTE SMOOTH TRANSITION FROM URANIUM TO PLUTONIUM FUELS.
- REDUCE COST OF URANIUM ENRICHMENT BY 50 PERCENT.
- MAINTAIN U.S. LEADERSHIP IN URANIUM ISOTOPE SEPARATION.

Viewgraph 14

The mission of the advanced isotope separation (AIS) program, which is shown on viewgraph 14, is to develop a technology to reduce the cost of uranium enrichment by at least 50 percent. Such a technology will support the transition from a nuclear economy based primarily on light water reactors fueled by uranium to one based primarily on breeder reactors fueled by plutonium.

A low capital cost uranium enrichment technology would facilitate the addition of increments of new enrichment capacity to evolving requirements of a growing LWR industry and also provide a way to decouple rapidly increasing SWU prices from the cost of power.

**DEPARTMENT OF ENERGY**

## CIVILIAN NUCLEAR PROGRAMS
## BUDGET SUMMARY
### (BA in Millions)
### ADVANCED ISOTOPE SEPARATION

| | FY 1981 | FY 1982 |
|---|---|---|
| ADVANCED ISOTOPE SEPARATION TECHNOLOGY | $79.3 | $85.3 |
| PROGRAM DIRECTION | 0.9 | 1.2 |
| TOTAL | $80.2 | $86.5 |

VIEWGRAPH 15

The budget request for the advanced isotope separation program in fiscal year 1982, shown on viewgraph 15, is $86.5 million in budget authority compared to $80.2 million in fiscal year 1981.

Since the remainder of my testimony is rather lengthy, I would like to request your permission to submit it for the record and briefly highlight the main points with the viewgraphs.

Mrs. BOUQUARD. Without objection, that will be a part of the record.

## COST PROJECTIONS
## 9 MILLION SWU PLANT

| FORM OF URANIUM | CONTRACTOR | CAPITAL COST ESTIMATE | SWU COST ESTIMATE ($/SWU) |
|---|---|---|---|
| MOLECULAR | LASL | $935M | 28 |
| ATOMIC | LLL | $670M | 21 |
| PLASMA | TRW | $880M | 30 |

VIEWGRAPH 16

Dr. DILLON. Viewgraph 16 really shows the main points of the advanced isotope separation program, which all result from the benefits that accrue to our nuclear program by a dramatic reduction of the capital cost of enrichment technology. This will lead not only into savings in terms of our nuclear utilities and the component of their fuel cycle charges for enrichment, but also will give us increased flexibility in adjusting our enrichment strategy due to the lower front-end costs. In addition, these low costs would certainly improve our posture as a foreign supplier and give us a fairly substantial competitive edge.

The program itself is based on three processes: A molecular process, which is being developed principally by the Los Alamos National Laboratory; an atomic vapor process being developed by the Lawrence Livermore National Laboratory; and a plasma process being developed by TRW. The capital cost estimate numbers are, as you can see, slightly less than $1 billion.

An equivalent size plant, amortized, using the same assumptions, using advanced centrifuge technology, would cost somewhere between $3 and $4 billion, so there is a rather significant capital cost savings.

In addition, the separate work costs, which you can see ranging from $21 to $30, compares very favorably with the charges in this country now and abroad, which are now over $100.

## ADVANCED ISOTOPE SEPARATION PROGRAM

| FY 1982 | | MID FY 1982 | | FY 1986/ FY 1987 |
|---|---|---|---|---|
| PREPROTOTYPE TESTBEDS | ➡ | SELECT PROCESS | ➡ | DEVELOPMENT MODULE |

VIEWGRAPH 17

Viewgraph 17 outlines the basic strategy. It is simply an engineering scale-up and verification. The strategy has been modified slightly to provide for process selection prior to the definition of and the commitment to a developmental module which is the facility on the right-hand side of the graph, which will culminate this phase of the program's development.

Let me turn briefly to each of these two stages.

## PREPROTOTYPE SYSTEMS

## OBJECTIVES

- FIRST SEMI-INTEGRATED SYSTEM AT REASONABLE SCALE.
- EVALUATE SYSTEM SCALING PARAMETERS.
- RESOLVE SCIENCE ISSUES.
- DEVELOP DATA BASE TO SUPPORT ENGINEERING DEVELOPMENT.

VIEWGRAPH 18

The objectives of the first stage, which we call preprototype, are shown on viewgraph 18. When I say there "the first semi-integrated system demonstrated at a reasonable scale," I mean a scale that is large enough to permit a high confidence extrapolation. The actual scaling factors involved range anywhere from full production plant scale up to scaling factors as large as 1,000.

But in any case, we feel we have kept scaling into regions where they can be projected with considerable confidence. We will evaluate the system scaling parameters by tracing how well we actually obey the scaling laws in those areas where we are doing substantial scaling. We will resolve all of the fundamental science issues associated with these three processes.

And finally, we will develop, based upon operation of these preprototype systems, the data base we will need to make the engineering decisions on the next stage of development, which is the development module.

## DEVELOPMENT MODULE

## OBJECTIVES

- FIRST FULLY INTEGRATED PROCESS DEMONSTRATION.
- DEMONSTRATE MINIMUM ACCEPTABLE RELIABILITY.
- DEVELOP FIRM DATA BASE TO PROJECT PLANT ECONOMICS.
- EXPLORE OFF DESIGN OPERATING PERFORMANCE.

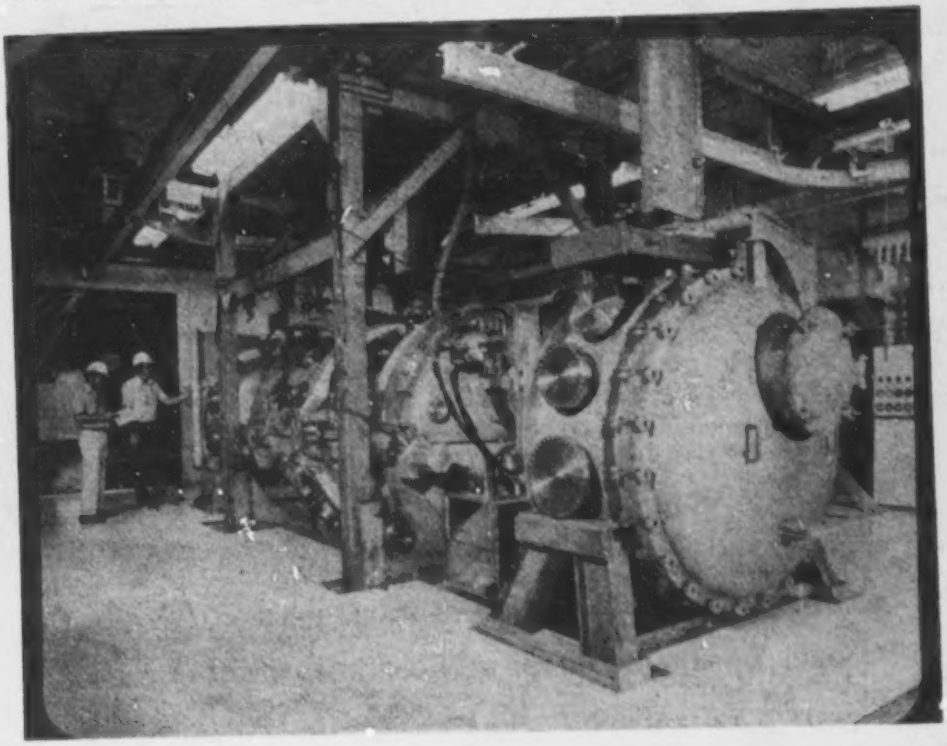
VIEWGRAPH 19

That brings me to the objectives for the development module, as shown on viewgraph 19. That would be a fully integrated process demonstration: that is, all aspects of the process from the feed of the materials to the final product preparation. We will be able to demonstrate minimum acceptable reliability to achieve our economic goals, and we feel that we will get a firm data base to allow us to project the plant economics with considerably greater accuracy; in fact, enough accuracy to allow one to consider moving the commitment to the next step up, which would be heading toward production plant capabilities.

And finally, with the development module, we will be able to explore in detail off-design operating performance: that is, what happens when a laser or a magnet doesn't work, and what happens to the overall system, and what happens to the plant reliability, and finally what happens to the economics if this happens.

These facilities themselves will represent, depending upon which process is selected, anywhere from a quarter of a million to maybe half a million SWU. So we will have a fairly substantial enrichment capacity. And most of the components that will be in this facility will be demonstrated to full production scale.

Now, although many of the accomplishments in this program are classified, and can't be discussed at this hearing, I would like to briefly give you a status report for the advanced isotope separation program in some of the pieces of hardware that indicate where we are within the program.



VIEWGRAPH 20

Mr. DILLON. Viewgraph 20 is for the atomic vapor process. It is the actual facility that allows us to produce the atomic vapor. It will operate at full production plant specifications both in terms of the rate of vaporization of uranium and the efficiency, the thermal efficiency, with which that uranium is evaporated.

All vapor physics issues can be addressed in this system. Those clam-like parts on both ends are where the optics are, and the business end is in the center, and that is where the uranium boat will be. There will be an electron beam which will vaporize the uranium and allow it to go up.

Mrs. **Bouquard.** Which one of the plants is this?

Dr. **Dillon.** This is the atomic vapor process being developed by Lawrence Livermore National Laboratory.

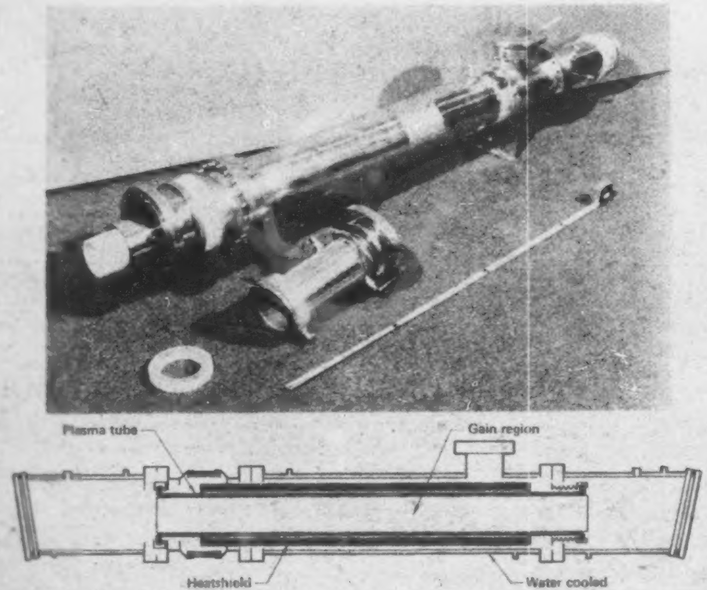
Mrs. **Bouquard.** Lawrence Livermore?

Dr. **Dillon.** Yes. An atomic vapor source is also being developed at Oak Ridge by the nuclear division of Union Carbide Corp.

Mrs. **Bouquard.** Atomic vapor?

Dr. **Dillon.** Yes, for the atomic vapor. It is even more advanced than this particular facility. But it won't be operational for some time.

LARGE BORE CYLINDRICAL LASER

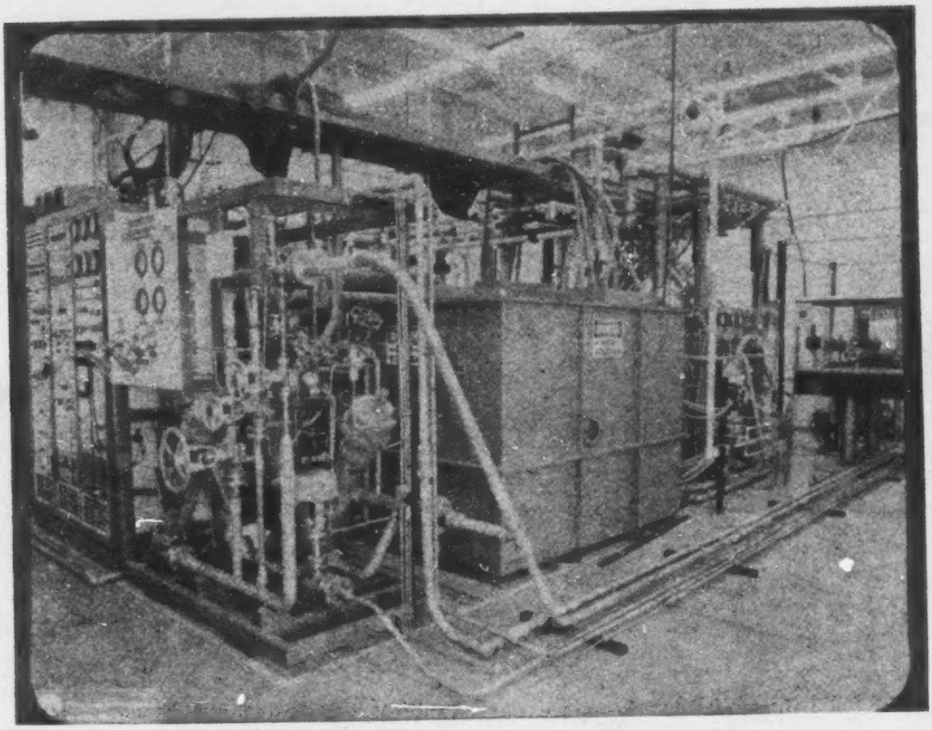


Viewgraph 21

The copper vapor laser, shown on viewgraph 21, is the key to the atomic vapor process. It is the basic building block for their laser system. This particular laser, which has been successfully developed by Lawrence Livermore, is 80 percent of the production plant size, and its demonstrated lifetime is in excess of 300 hours. Now, that is almost 15 percent of the economic plant requirement, so when you consider the learning curve, how sharp it is for lasers, this is a very encouraging result.

The design uses existing materials and straightforward fabrication procedures, so it has low unit cost. An actual operating plant would use hundreds of these kinds of lasers.

Now, I would like to return to the molecular process being developed at Los Alamos National Laboratory.

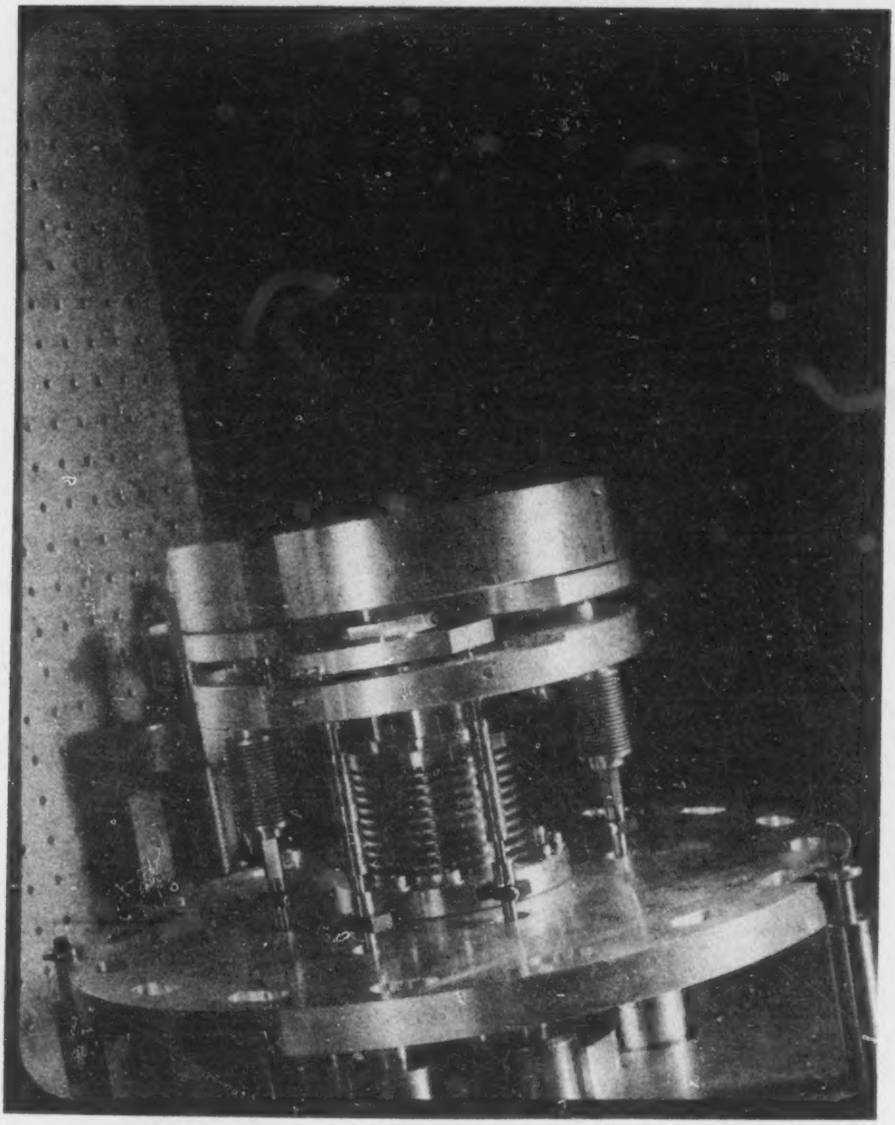


VIEWGRAPH 22

Viewgraph 22 shows their ultraviolet laser system, which is one of the most economically sensitive components of their plant.

This particular facility will be replicated. It is, right now, designed to operate at 25 percent of what would be the plant power requirement. That is 1 joule per pulse. It is being manufactured for Los Alamos by the Rocketdyne Corp. They plan to deliver it in the very near future.

The fourth area has to do with the infrared part, shown on viewgraph 23.



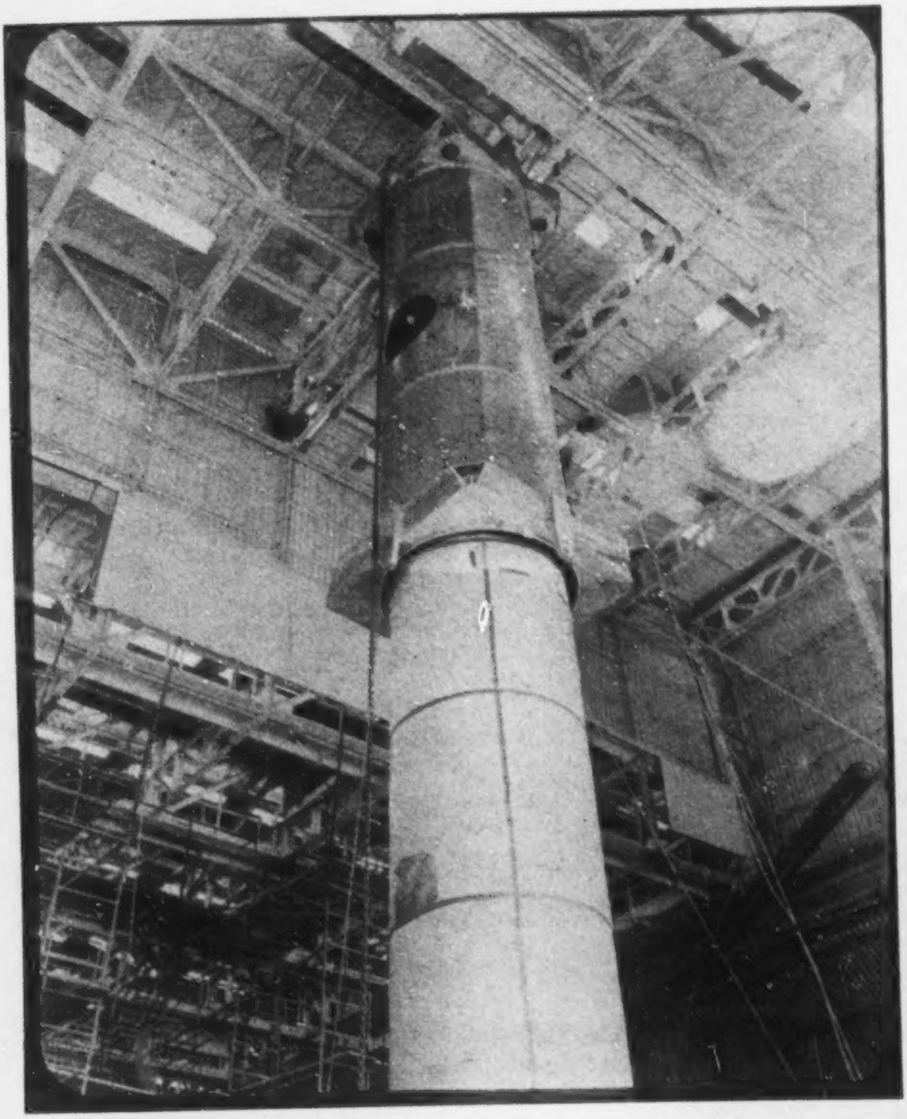
Viewgraph 23

The Los Alamos approach requires two different kinds of lasers, an ultraviolet and infrared laser. And the infrared laser has been a very difficult part of the development program.

What they are able to do, using the cell, is to use a very inexpensive carbon dioxide laser, which is a relatively cheap laser that works with extremely high efficiency to then convert the carbon dioxide laser radiation to the desired radiation.

In this Raman cell, they use hydrogen molecules to scatter and shift this infrared radiation to the desired frequency. Viewgraph 23 shows the very high reflectivity upper mirror that will reflect 99 percent of all of the infrared.

The last piece of equipment I want to show you is a large superconducting magnet, as shown on viewgraph 24.



Viewgraph 24

It is the key to the preprototype system for the plasma separation process being developed by TRW.

This picture shows the casing being placed on the magnet. It has an inner bore of about 1 meter, and it is 4 meters long. It gives a uniform, extremely uniform field, about 20,000 times stronger than the Earth's magnetic field.

This magnet is, as I said—with the 1-meter bore—about one-fourth the size of the magnet that would be needed for a full production plant.

When this facility is operating, it will actually constitute almost 17,000 separate work units of capability.

Well, that completes my overview of the advanced isotope separation program.

Mrs. Bouquard. What process was this?

Dr. Dillon. This was the plasma separation process. It is based upon radiofrequency. It goes into a plasma that is generated inside a magnetic field; and, at exactly one resonant frequency, called the cyclotron frequency, one of the types of uranium will actually begin to spin in ever-increasing-size orbits.

Mrs. Bouquard. This work is performed at the TRW Co.?

Dr. Dillon. Yes.

Mrs. Bouquard. Well, I'm confused. I thought JNAI developed an atomic vapor process.

Dr. Dillon. JNAI has also developed, in parallel with Lawrence Livermore National Laboratory, an atomic vapor process which is similar in terms of its basic science, but different in terms of its engineering.

But they were activities that were developed in parallel, starting in the early 1970's.

Mrs. Bouquard. Thank you.

On our program on enrichment, does the plan call for accelerated introduction of the advanced isotope separation technologies? Are we going to accelerate this? What is the time frame on our schedule?

Dr. Dillon. No. We are basically keeping with our baseline strategy, which calls for making a process selection during fiscal 1982. And then, after that process selection is made, at that time we will define what would be the optimum pace and scope for the development module. So, it doesn't constitute a substantial acceleration of what has been our main strategy in the last couple of years.

Mrs. Bouquard. Do you anticipate any problems in meeting our 1981 milestone?

Dr. Dillon. No. We continue to have good progress on almost all the milestones. Like any other technical milestones, they are not always met with extreme precision. But, in terms of the overall intent of what we need to get done, the milestones have been met.

Mrs. Bouquard. Do you still believe that a decision on the selection of one technology can be made in fiscal year 1982?

Dr. Dillon. Yes. We do.

Mrs. Bouquard. Involvement of JNAI with this program was requested by this Committee.

Has this happened?

Dr. Dillon. During the first 3 months of the fiscal year, we entered into a contract with JNAI, at which time we carried out a detailed assessment of not only a proposal they had made, but also assessed their technology in general, attempting to compare the technology developed by Jersey Nuclear with the technology developed by Lawrence Livermore, making equivalent assumptions.

And that has been the extent of our activity with JNAI.

Mrs. **Bouquard**. This was the assessment of their proposal?

Dr. **Dillon**. This was an assessment of their proposal; but also an assessment of their technology.

Mrs. **Bouquard**. Was there pretty general agreement among the members of the board?

Dr. **Dillon**. There was no board. This was an assessment that was carried out by the Department of Energy staff, in conjunction with our contractors at both Livermore and Union Carbide, helping with aspects of it.

But because there was proprietary information involved, we couldn't get broad involvement.

In addition, we had an ERAB report—Energy Research Advisory Board—look at the issue, in general terms, on what would be the best course of action for the Department to take with regard to their proposal that they had made.

They made two recommendations that bear on this:

The first recommendation was that the proposal, in its existing form, be rejected.

The other recommendation was that JNAI represented a significant industrial competence, and a potential boost for the program; and that the Department should look at every way possible to get them involved in the program.

[The prepared statement of Dr. Dillon follows:]

## Statement of Dr. Thomas A. Dillon, Deputy Assistant Secretary for Nuclear Reactor Programs, Department of Energy

### ADVANCED ISOTOPE SEPARATION PROGRAM

Madam Chairman and Members of the Subcommittee, I am pleased to appear before you to discuss the Department of Energy's Advanced Isotope Separation (AIS) Program.

The mission of the Advanced Isotope Separation (AIS) Program is to develop a technology to reduce the cost of uranium enrichment by at least 50 percent. Such a technology will support the transition from a nuclear economy based primarily on light water reactors fueled by uranium to one based primarily on breeder reactors fueled by plutonium. A low capital cost uranium enrichment technology would facilitate the addition of increments of new enrichment capacity to evolving requirements of a growing LWR industry and also provide a way to decouple rapidly increasing SWU prices from the cost of power.

The budget request for the Advanced Isotope Separation (AIS) Program in fiscal year 1982 is $86.5 million in budget authority compared to $80.2 million in fiscal year 1981. Statutory authority for this activity is contained in the Atomic Energy Act of 1954 as amended by Section 16, Public Law 88-489.

Excellent progress on the molecular, atomic vapor, and plasma processes we have been pursuing in the AIS program continues. As a result, we are now planning a major technical review to select by mid fiscal year 1982 one of these three processes for a major engineering development effort, although major construction will not be initiated until fiscal year 1983. Many scientific and technical issues have been resolved. The remaining scientific issues and the engineering aspects of the technologies can best be solved by going to larger systems.

Prior to process selection, the near term objective of the Advanced Isotope Separation Program strategy involves the operation of semi-integrated testbed systems which we have called preprototype systems. The preprototype systems will demonstrate the scientific principles of the AIS technologies using scaled-up components. Construction of the preprototypes should be completed by the end of 1981. In fiscal year 1982 a comprehensive economic, technical, and environmental evaluations of the techniques will be completed to determine if the available data warrants proceeding to full engineering developement. Assuming a decision is made to proceed with engineering development, an engineering Development Module (DM) could be operational in the latter half of the 1980's. The operation of this module would demonstrate a fully integrated process with sufficient reliability to develop a firm basis for determining production costs. In addition, the Development Module would be used to explore the off-design operating performance of the technology.

Because of classification, I cannot now discuss the detailed accomplishments and future specific milestones of the program. We have, however, met with the Committee staff members to inform them of the program's progress and would be happy to provide the Committee with additional information on a classified basis as desired.

In early fiscal year 1982, efforts will be concentrated on the initial operation of the preprototype testbed systems. The preprototype systems require lasers of higher power and repetition rate than have been previously operated, larger magnet systems, and larger source and extractor subsystems. One of the major objectives of the preprototype systems will be to identify any scaling issues which could be associated with the AIS technologies.

The molecular process has been under development at the Los Alamos National Scientific Laboratory. Major efforts have been directed toward: (1) increasing the basic understanding of the interaction of the process gas and laser energy, (2) acquiring the infrared and ultraviolet lasers to be used in the large testbed, and (3) increasing the average power output per laser and increasing the lifetime of the laser. Although much progress has been made, some science issues remain concerning the interaction of the laser energy and the process gas. The science associated with demonstrating an economical enrichment factor should be completed near the end of 1981.

The atomic vapor process has been under investigation at the Lawrence Livermore Laboratory and has stressed work relating to: (1) developing lasers having higher average power output per laser and longer lifetimes, (2) increasing the lifetime of materials exposed to liquid uranium and uranium vapor, and (3) developing an extractor capable of operating at the densities required for a production module. Design and fabrication of the uranium handling system began in fiscal year 1979. The uranium handling system includes both the uranium vapor source and the structure required for the transport of uranium.

The plasma process has been under development by TRW, Inc. Major efforts have been directed toward: (1) increasing the routine operation of scalable plasma sources, (2) establishing the scaling laws and increasing the scientific knowledge of the plasma process, and (3) developing materials for collectors that have the necessary properties and lifetimes. Some science questions on the plasma process remain to be resolved. The operation of the preprototype magnet system should resolve the key science issues associated with plasma scaling.

The preprototype testbeds will be operated for approximately three months before a decision is made to proceed to the engineering development phase of the program. We believe that the operation of this facility and the successful completion of the Development Module in the latter half of the 1980's will permit the introduction of an AIS production capability in the early to mid 1990's.

Mrs. BOUQUARD. Thank you very much.

Mr. Lujan?

Mr. LUJAN. Thank you, Madam Chairman.

I don't really know where to begin, except to ask the very basic questions.

What you are doing now is looking at three different types of lasers.

And then, in 1982, you will make the decision which is the one that is best applicable to isotope separation?

Dr. DILLON. Three different kinds of processes, two of which are based on lasers; and one of which is based on radio frequency. The plasma one doesn't use lasers; it just uses radio frequency technology.

And we will make a selection on which one is the most promising. We are hopeful that we will have to select from three extremely promising options. But our task is to pick the one which shows the greatest promise, in terms of least risk and greatest cost savings.

Mr. LUJAN. In setting that date, that is kind of unusual in research projects, isn't it?

Normally—with all due respect—scientists can always find more things to look at, as time goes on. But you have set a 1982 date when that decision is going to be made, and you expect that to hold pretty well?

Dr. DILLON. Yes, sir. And the phenomenon that you mentioned is a very operable one.

Mr. LUJAN. We had Admiral Rickover here yesterday. He told us about his light water breeder program that you study it more, because there are still more things to find out.

Mrs. BOUQUARD. If the gentlemen would yield at this point.

It may seem like yesterday, but I think it was the day before yesterday.

[Laughter.]

Mr. LUJAN. The whole idea, I suppose, is that isotope separation is going to be less expensive than the other two methods that we are using now. Is that basically it?

Dr. DILLON. Yes, sir.

Mr. LUJAN. When you take everything else into consideration—construction and whatever else you have to build, and less electricity, but more of something else, perhaps—what does that look like?

Dr. DILLON. Well, maybe we could put that first chart back up again.

In terms of capital costs, it yields a very substantial reduction in the initial capital cost—and, because of that, there is an extremely significant reduction in the total cost for separative work.

The figure on the righthand side includes all of the operating factors—such as electricity, shipment, product, insertion, and withdrawal. That is a total, sort of a bottom-line number.

I do need to emphasize, though, that these numbers now are projections that are made for us by our contractors at Union Carbide, and they are based on scientific input. And they don't reflect yet, at this time, the comprehensive engineering validation of the assumptions.

So, some caution has to be used.

Mr. LUJAN. Let me give you a little tip on what you ought to do. I was looking at some figures for the fusion materials irradiation test facility, and Los Alamos was the closest estimate. They also really estimated exactly on the cost of the tritium system test assembly facility. That was right on the money.

So, probably the top one is the one that is more accurate.

[Laughter.]

Mr. LUJAN. So, depending upon which one you choose, does that necessarily mean that that is where the facility is going to be built?

Dr. DILLON. No. The plan we have now is that the development module will be at Oak Ridge. And that, depending upon who is selected, they will have a major supporting activity.

Mr. LUJAN. What are we going to do with Oak Ridge and the Portsmouth plants, then, after this real efficient program comes in? Or are we going to run all three?

Dr. DILLON. Well, the time scale for this is subsequent to the Portsmouth GCEP project. So this won't be in time for that particular application.

In terms of the diffusion plants, they are getting older, and the power costs associated with operation of those diffusion plants have been rising, and will continue to rise. At these kinds of costs, it would be economically efficient to replace them.

Mr. LUJAN. How about the centrifuge?

Dr. DILLON. The main costs of the centrifuge are the capital costs. If you had an existing centrifuge facility, it would not be economic to replace it. It uses about the same amount of electricity and the same amount of operating expenses as this kind of a plant.

The main savings of these types of facilities, as compared to centrifuge, aren't in operations, but in the capital costs.

Mr. LUJAN. So, once you have it——

Mr. GATES. I think the question you asked, sir, is certainly a valid one. But I think that it would be premature to try to answer it today.

Mr. LUJAN. Well, will we probably need both of them?

Mr. GATES. I think that is conceivable, too. Very conceivable.

Mr. LUJAN. Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much.

Mr. Forsythe?

Mr. FORSYTHE. No questions, Madam Chairman.

Mrs. BOUQUARD. I was just curious. You had the cost for the 9 million SWU plant.

What do you estimate a 9 million centrifuge plant would cost?

Dr. DILLON. The GCEP technology, which is the technology that's actually going to be installed in the initial round at Portsmouth, isn't as advanced as some of the others.

For it, the capital costs would be quite high, using these assumptions. And the capital costs for it, in 1982 dollars, are on the order of $6.4 billion.

Now, for the more advanced centrifuge technology, that they called "set 4" and "set 5," which is, I think, probably a fairer and sounder comparison, the set 4 technology would be $3.7 billion, using the assumptions; and $3.1 billion for set 5.

So, that is the rough order of comparison.

Mrs. BOUQUARD. Thank you very much. I have just one followup question.

Since it was directed by this Committee that JNAI proceed on an equal footing with the other participants in this program, will they be involved in the fiscal year 1982 decision?

Mr. GATES. We feel that the evaluation given the JNAI proposal was equal to that given other proposals. We have had not only several exchanges of correspondence with the executives of JNAI, but we have also had a series of meetings. We think we are close to concluding the discussions and coming to a decision as to the extent to which JNAI may or may not participate with currently conceived Federal programs. We should know the answer to that question within a matter of days.

Mrs. BOUQUARD. Well, you said that the board decision indicated that they had the industrial competence, but it would involve more money for their participation in the program? Dr. Dillon?

Mr. GATES. May I make a response, and then I will ask the gentlemen who are more closely engaged in that program than I to extend the remarks?

The JNAI proposal initially was for about $165 million. The ERAB judgment was that that proposal should not be accepted. That was our judgment also, that that proposal should not be accepted. True, ERAB did point out that JNAI had a high degree of technical and scientific competence and that they represented a viable, credible team. The question was—with which we have been grappling—as to the extent to which JNAI's personnel and facilities and efforts could be incorporated with the ongoing somewhat similar program under the cognizance of Union Carbide and Lawrence Livermore National Laboratory.

Mrs. BOUQUARD. That is what I was getting at. Can they help?

Mr. GATES. We were trying to find that out, Madam Chairman. We felt they could help. The question was to what extent, reduced to dollars, were we able to accept their help, and we had our reaction to that; JNAI had their reaction to that; and I don't know what has happened today, but I think in a couple of days we will know.

Mrs. BOUQUARD. Thank you very much. Are there further questions.

Mr. LUJAN. Yes.

Mrs. BOUQUARD. Mr. Lujan?

Mr. LUJAN. What are other countries doing in this area of isotope separation? I'm thinking about the cost, the competitiveness with other countries.

Dr. DILLON. Mr. Lujan, I'm not certain about the classification that is associated with this, so I'm going to ask Frank Coffman to answer this question.

Mr. LUJAN. I'm just asking a commercial question as to competitiveness with other countries.

Mr. COFFMAN. As you probably know, the French have, like the United States has, a very aggressive gaseous diffusion program with colocated light water power reactors to power them. They are pursuing advanced separation technologies, particularly the French. And perhaps I should not mention the process, but it is not gaseous diffusion.

There are other countries in particular—Israel and France and the Soviet Union—who are looking at advanced isotope separation programs quite similar to ours. My perception of those programs is that they are science-based-oriented and are not competitive in terms of the state of progression that we are, which is to reach an imminent decision to proceed with the engineering phase of the program.

Mr. LUJAN. One final thing that occurs to me. Supposing you pick one, and the two remaining processes are in the industrial sector being developed. Are they free to go and license it, if they are not the one picked, if they come along and develop it?

Dr. DILLON. There are restrictions. Enrichment technology is a sensitive technology. It has the capability to produce special nuclear materials, so that a private firm, even on a privately funded basis, is subject to controls by the Government, and so they don't have a total carte blanche to license overseas.

Now, for example, JNAI, though, has overseas patents, and they can establish——

Mr. LUJAN. Which they have developed over there?

Dr. DILLON. Based upon work they developed here, they filed for overseas patents and have gotten quite a few of them. I don't know the exact number.

Mr. LUJAN. But they are limited as to what they can sell of their technology? Did they develop it with the Government's funds? I thought it was Exxon funded.

Dr. DILLON. JNAI up until 3 months ago was exclusively privately financed.

Mr. LUJAN. But you can still tell them what to do with it?

Dr. DILLON. We can tell them what to do, but they are——

Mr. LUJAN. You can tell them what not to do?

Dr. DILLON. There are certain restrictions that they are subject to, certain controls that they have to respect.

Mr. LUJAN. Thank you, Madam Chairman.

Mrs. BOUQUARD. Thank you very much. If there are no further questions, I want to again thank you for your fine testimony. It was very inclusive and very much to the point, and you are certainly well prepared.

This Committee will meet in the morning in room 2318 at 9 o'clock where we will resume our hearings on enrichment and spent fuel.

If there is no further business, the Subcommittee stands adjourned.

[Whereupon, at 4:20 p.m., the hearing was adjourned.]

# 1982 DEPARTMENT OF ENERGY AUTHORIZATION

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## FRIDAY, MARCH 20, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Research and Production,
*Washington, D.C.*

The subcommittee met, pursuant to notice, at 9 a.m., in room 2318, Rayburn House Office Building, Hon. Marilyn Lloyd Bouquard (chairman of the subcommittee) presiding.

Present: Representative Bouquard.

Mrs. Bouquard. The subcommittee will come to order.

Good morning, ladies and gentlemen. Today is our fifth and final day of hearings with administration witnesses on the Department of Energy's fiscal year 1982 annual authorization request.

Today we will consider the Department's uranium enrichment program and the advanced nuclear systems program.

The uranium enrichment program includes the management and operation of the Government's three gaseous diffusion enrichment plants located at Portsmouth, Ohio, Paducah, Ky., and Oak Ridge, Tenn.

It includes the Government's research programs in new enrichment technology. And finally, it includes the national uranium resource assessment program.

The committee has been a strong supporter of DOE's goal of being a reliable supplier of enrichment services to both domestic and foreign customers. In doing so, we recognize that DOE must perform research on improved methods of enrichment, such as centrifuge, plasma, and laser enrichment, if it is to remain truly competitive in a world where the U.S. monopoly on enrichment services has evaporated and significant foreign enrichment capabilities have been launched.

I believe it is important to recognize that the prices that DOE charges to consumers of enrichment services completely recovers the expenses for operation of the enrichment plants and for all research work, so that the activity is entirely self-sustaining.

Because of the necessity of paying in advance for certain activities of enrichment sales, and of the inherent uncertainty of estimating costs, the DOE usually requires an annual appropriation, which is later returned to the Treasury as enrichment services are sold.

This is significant, in that for fiscal year 1982, the total DOE enrichment budget is about $2 billion of which an appropriation of only $154 million is being requested.

The self-sustaining nature of the uranium enrichment business is not, however, a mitigating factor in the committee's responsibility to see that the program is properly managed.

Ultimately, it is Congress' responsibility to lead this program in the proper direction.

Some of the issues that the committee is concerned with today, and would like to hear further from the witnesses, are whether the operation of the enrichment plants, at their minimum capacity, poses any risk of permanent damage to the barrier material as a result of nonuse; whether the cascade improvement programs are being completed on schedule and within originally anticipated costs, and, finally, whether the centrifuge enrichment plant is truly an economically justifiable investment which should proceed toward completion without further delay.

The other program we will be considering today is the advanced nuclear systems program, which is a much smaller program by comparison, totalling approximately $38 million for fiscal year 1982.

This program, in part, is set up to engineer and qualify nuclear-powered thermoelectric generators for use in spacecraft and other remotely located devices.

The program will also lead to the development of a space nuclear reactor for the high energy needs of deep space.

Another important part of this program is the demonstration of the technology for nuclear irradiation of sewage sludge to make fertilizer.

Albuquerque, N. Mex., is the first city to select this process for demonstration, and will build, with DOE support, a facility to process 33 tons of sewage sludge per day.

Of prime importance to the committee is the issue of whether the funding aimed at space power sources should be assumed by the Department of Defense or NASA, which are the primary benefactors of this program.

The subcommittee will also want to monitor closely the progress of the Department of Energy in its sewage sludge irradiation project.

This technology could have widespread civilian use if a timely and proper demonstration is made.

These are some of the issues that the subcommittee will be looking at this morning.

I am pleased to welcome our panel of witnesses from the Department of Energy.

We are fortunate to have with us again today, Mr. Mahlon Gates, the Acting Assistant Secretary for Nuclear Energy, Dr. Thomas Dillon, Deputy Assistant Secretary for the Nuclear Reactor Programs, Mr. William Voigt, Director of the Office of Uranium Resources and Enrichment, and Dr. Frank Coffman, the Director of Advanced Nuclear Systems and Projects.

Is he here today?

Mr. Gates. We had anticipated his presence.

Mrs. Bouquard. Shortly, I will be turning the Chair over to Mr. Volkmer.

You may proceed with your testimony.

## STATEMENTS OF MAHLON GATES, ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY, U.S. DEPARTMENT OF ENERGY; THOMAS A. DILLON, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR REACTOR PROGRAMS; WILLIAM R. VOIGT, JR., DIRECTOR, OFFICE OF URANIUM RESOURCES AND ENRICHMENT; AND FRANK COFFMAN, DIRECTOR OF ADVANCED NUCLER SYSTEMS AND PROJECTS

Mr. GATES. Thank you, Madam Chairman.

It is a pleasure once again to appear before your committee. Before I turn the testimony over to Dr. Dillon, who will be the lead-off witness on advanced nuclear systems, I would like to make one observation about the Office of Uranium Resources and Enrichment.

That office has recently been assigned to the Assistant Secretary for Nuclear Energy as it was earlier a part of the Office of the Assistant Secretary for Resource Applications which was disestablished under the recent reorganization of the Department of Energy.

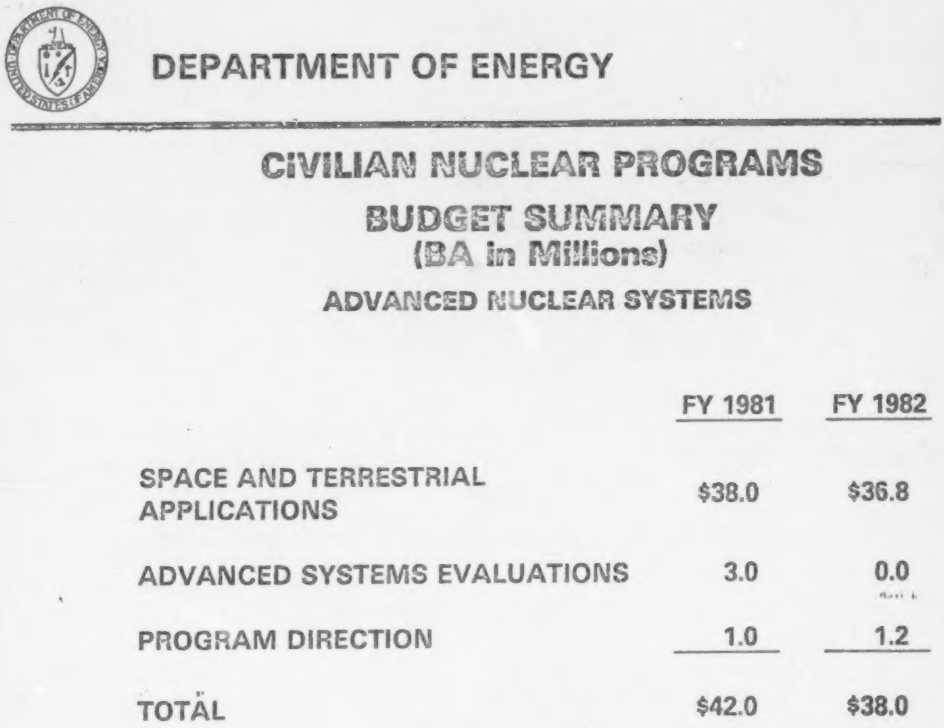
I would like to now call on Dr. Dillon.

Mrs. BOUQUARD. Dr. Dillon, you may proceed with your testimony, and without objection, your complete statement will be made a part of the record.

Mr. DILLON. The activity of the advanced nuclear systems is composed of two major program elements: Space and terrestrial applications and advanced systems evaluation.

The budget request for this activity for fiscal year 1982 is $38 million in budget authority, a reduction compared to $42 million in fiscal year 1981. Statutory authority for these activities is contained in the Atomic Energy Act of 1954, as amended, Public Law 83-703.

The budget request for the ANS activity is summarized on viewgraph No. 1.



DEPARTMENT OF ENERGY

## CIVILIAN NUCLEAR PROGRAMS

## BUDGET SUMMARY

(BA in Millions)

### ADVANCED NUCLEAR SYSTEMS

| | FY 1981 | FY 1982 |
|---|---|---|
| SPACE AND TERRESTRIAL APPLICATIONS | $38.0 | $36.8 |
| ADVANCED SYSTEMS EVALUATIONS | 3.0 | 0.0 |
| PROGRAM DIRECTION | 1.0 | 1.2 |
| TOTAL | $42.0 | $38.0 |

VIEWGRAPH 1

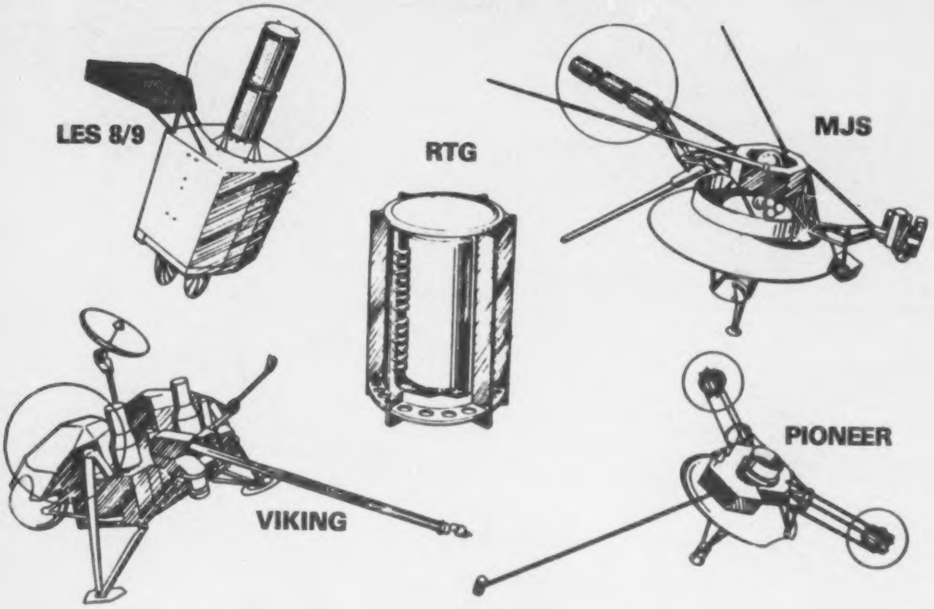
The main feature here is the advanced systems evaluations program will be terminated before 1982.

With your permission, I would like to summarize the program activities with a few additional viewgraphs.

Mrs. BOUQUARD. Without objection, please proceed.

Mr. DILLON. Viewgraph No. 2 shows some of our past successes in the space power systems program in terms of power systems that we have delivered for application by both the Department of Defense and NASA.

## ISOTOPIC POWER SYSTEMS SPACE APPLICATIONS DOD AND NASA



VIEWGRAPH 2

Probably many members of the committee are familiar with the recent accomplishments of the Voyager spacecraft which took photographs of the galileian satellites of Jupiter.

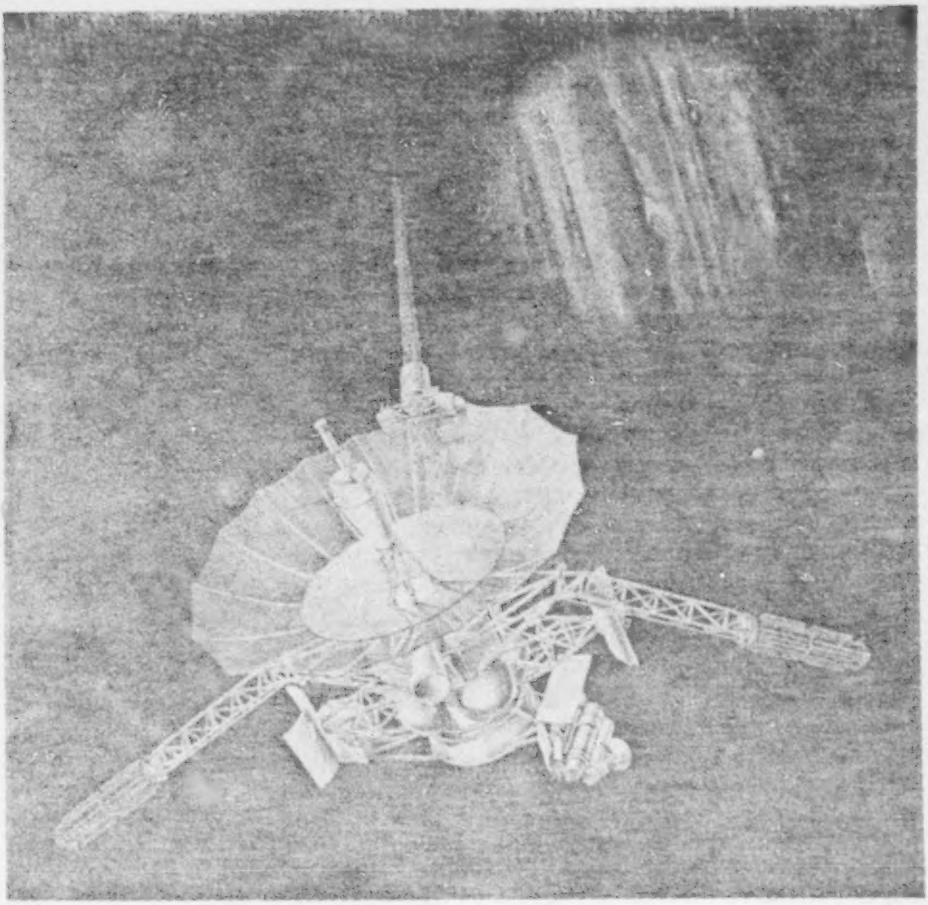
The unique ability of nuclear thermoelectric generators to provide reliable electricity at a vast distance from the Sun is one of the primary requirements for advanced nuclear systems of this kind.

We have had an extraordinarily fine track record.

Every single power supply that we have delivered has outperformed the specifications in terms of electrical capacity delivered, and in terms of lifetime, so we are proud of our past record.

The next viewgraphs summarize the major items that are contained in the 1982 budget. The first two are NASA missions that we are preparing for in 1985 and 1986, respectively, space reactor activities, and finally, sludge irradiation.

In terms of the Galileo mission, depicted in viewgraph No. 3, we are planning for a launch in 1985.



VIEWGRAPH 3

There will be two flight units required, power units of 280 watts each, and I think that this would be a good opportunity for me to describe very briefly the financial arrangements that we make with the user agency, because I think this will be important to understanding the issue of how much DOD, DOE funds and why.

On this mission, the two flight units that will actually be used on the spacecraft will be paid for by NASA.

Twenty million dollars will be reimbursed to the Department of Energy in the case of this mission. This has been a philosophy that the DOE and its predecessor agencies have pursued with DOD and NASA in the past.

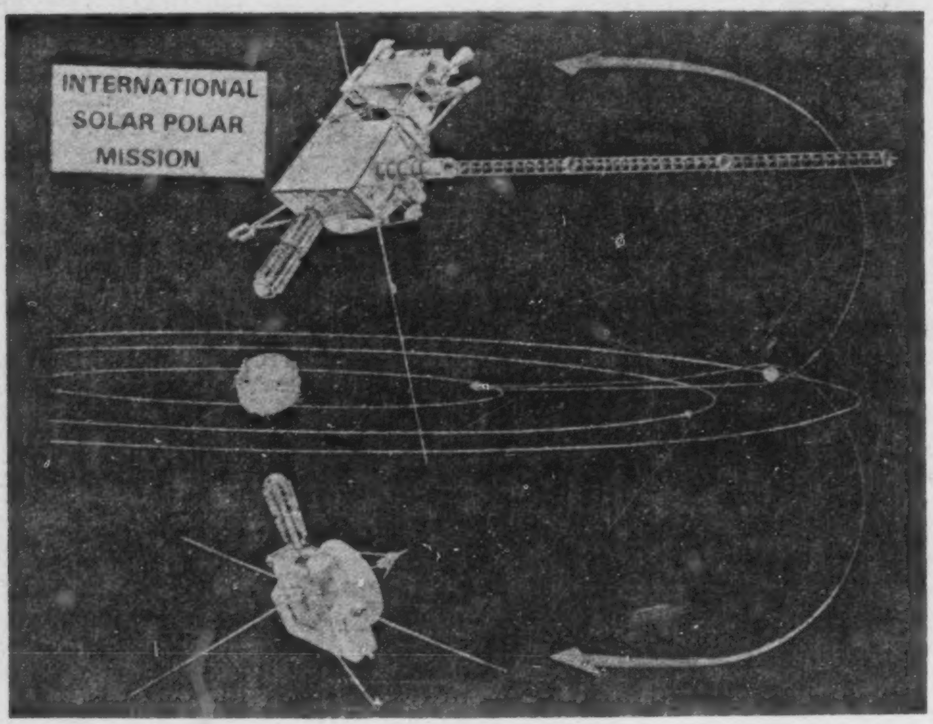
That is, that DOE pays for the first-of-a-kind cost for the research and development activities and the qualification units leading up to a mission.

Any replication, or if you will, off-the-shelf use of these power units by the user agency is fully reimbursed by the user agency, so that a lot, a large part of this program actually is reimbursed.

Now, one of the caveats I have to put on that is many of these missions have forced us to push the state of the art, so it has been a recurring theme that there has been a large development activity associated with almost every mission.

I think that the budget we are proposing shows a very interesting effect, that both the Galileo mission and the Solar Polar mission will use the same technology, so we won't be facing that persistent problem of having to go through large development programs for each mission.

Viewgraph No. 4 shows the Solar Polar mission.



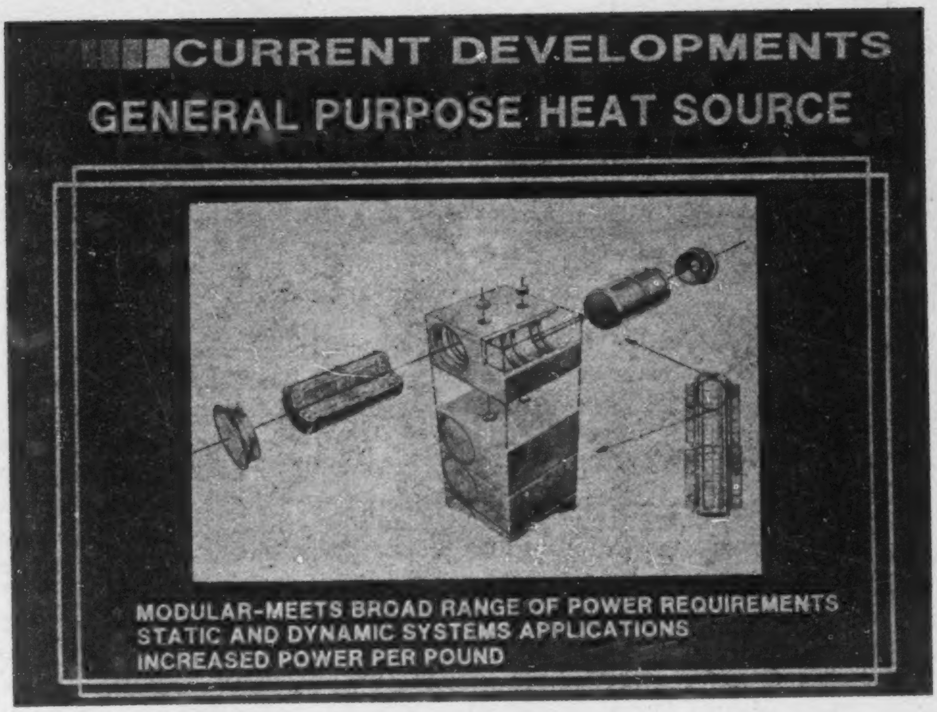
VIEWGRAPH 4

This is a joint mission with the European Space Agency and the United States. It is my understanding that the U.S. satellite spacecraft that was going to be part of this has been recommended for termination, so the mission that we will be planning on is support of the ESA, European Space Agency spacecraft by providing them with the flight generator.

We will be entering into discussions with NASA in terms of whether or not the flight unit that we deliver for that spacecraft will be reimbursable.

If it is, there will be a $10 million reimbursement for that.

Viewgraph No. 5 shows an important development which is, I feel, going to help reduce the amount of developmental costs associated with the conduct of this program.



CURRENT DEVELOPMENTS

GENERAL PURPOSE HEAT SOURCE

MODULAR-MEETS BROAD RANGE OF POWER REQUIREMENTS
STATIC AND DYNAMIC SYSTEMS APPLICATIONS
INCREASED POWER PER POUND

VIEWGRAPH 5

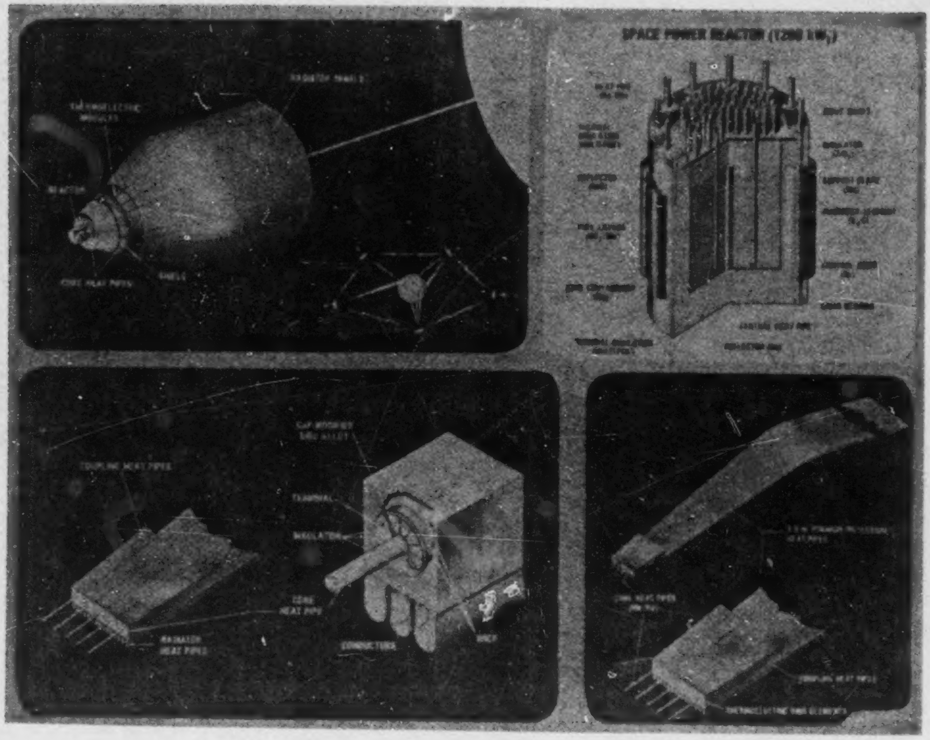
As I said earlier, in many cases, as we proceed from new mission requirements, we have to engage in large expensive development programs.

This general-purpose heat source is a modular concept, which can be used for a variety of missions.

It uses four, 62½-watt plutonium capsules, encapsulated in the iridium as a basic unit. The current advanced units that we have for Galileo and Solor Polar, we use 18 of these modules.

These represent advanced technology giving us a higher electrical performance per unit of weight than previous technology, and I think represents a significant advance, both for the user, but equally important for our own program in keeping our future costs to a minimum.

Viewgraph No. 6 shows our space reactor concept. We are working closely with both NASA and DOD in terms of defining what their needs are for this technology.


SPACE POWER REACTOR (1200 kWt)
RADIATOR PANELS
THERMOELECTRIC MODULES
REACTOR
CORE HEAT PIPES
SHIELD
COUPLING HEAT PIPES
TERMINAL
INSULATOR
CORE HEAT PIPE
RADIATOR HEAT PIPES
CONDUCTORS
COUPLING HEAT PIPES

Viewgraph 6

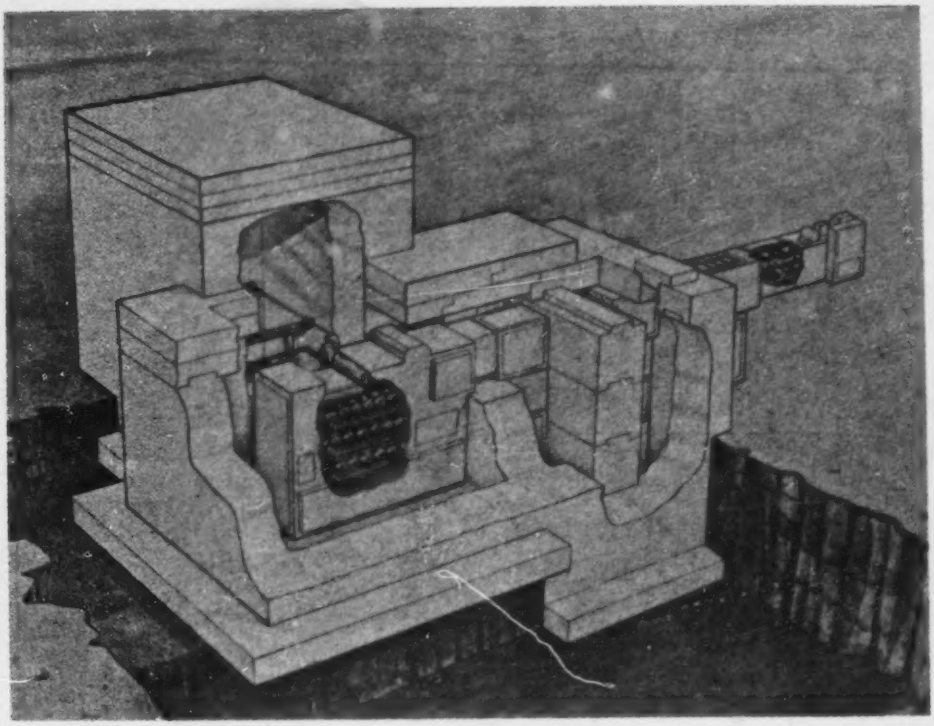
We feel this is the only reliable source of large amounts of electricity on the order of, say, 10 to 100 kilowatts, certainly, that can be found in out-of-earth orbit applications.

We have formed an inter-agency space power working group which is going to define the applications and submit a formal plan to a triagency steering committee, so that we can go forward with a program focusing in this area.

I would like to say that we have worked closely with NASA and have gotten them to contribute to some funding, so now the space reactor program will be a jointly funded NASA/DOE program, with the NASA contribution expected to be about $700,000 in 1982.

The final element that I want to talk about has to do with our sludge irradiation program. We have operated at the Sandia Laboratory, an 8-ton-per-day pilot plant to irradiate sewage sludge. This destroys the pathogens and helps us reuse the resulting bioproducts for profitable applications.

We are working with the city of Albuquerque in supporting them with the design of a 33-ton-per-day production facility, shown as an artist's conception in viewgraph No. 7, which hopefully will go into operation in 1984.



VIEWGRAPH 7

We will be completing a long, ongoing study of a nuclear energy center.

This is a nuclear energy center which has been investigated in South Carolina, that would be capable of siting 12 generating stations.

The final report will be in shortly.

The results certainly at this time do look encouraging for the energy center concept.

We will operate and characterize an advanced dry-cooling units and update our water use information system data bank which is unique in this country.

Mr. Chairman, that concludes my statement.

I would be happy to answer any questions you have.

[The prepared statement of Thomas A. Dillon follows:]

Statement of
Dr. Thomas A. Dillon
Deputy Assistant Secretary
for Nuclear Reactor Programs
Department of Energy
Before the
Committee on Science and Technology
Subcommittee on Energy Research and Production
March 20, 1981

## ADVANCED NUCLEAR SYSTEMS

Madam Chairman and Members of the Subcommittee, I am pleased to appear before you to discuss the Department of Energy's Advanced Nuclear Systems Program.

I am accompanied today by Dr. Franklin E. Coffman, Director, Office of Advanced Nuclear Systems and Projects.

The activity of the Advanced Nuclear Systems is composed of two major program elements: Space and Terrestrial Applications and Advanced Systems Evaluation. The budget request for this activity for FY 1982 is $38 million in budget authority, a reduction compared to $42 million in FY 1981. Statutory authority for these activities is contained in the Atomic Energy Act of 1954, as amended (PL 83-703).

The budget request for the ANS activity is summarized below.

Advanced Nuclear Systems Budget Summary ($ in thousands)

| | FY 1981 | FY 1982 |
|---|---|---|
| Space and Terrestrial Applications | $38,000 | $36,800 |
| Advanced Systems Evaluations | 3,000 | 0 |
| Program Direction | 981 | 1,200 |
| Advanced Nuclear Systems | $41,981 | $38,000 |

Program direction represents the costs of administering the program including federal employee salaries, benefits, and travel.

Madam Chairman, the remainder of my statement has already been submitted to you. With your permission, I would like to summarize it with additional viewgraphs.

## SPACE AND TERRESTRIAL APPLICATIONS

The DOE Space and Terrestrial Applications activities under the Advanced Nuclear Systems Program has been responsible for the development and fabrication of all U.S. nuclear space power systems launched to date. In FY 1982 the major space power development activities will continue to support the NASA Galileo spacecraft planned to be launched in 1985 and

International Solar Polar spacecraft currently planned to be launched in 1986. The Terrestrial Isotopes Applications activity will be focused only on the use of Cesium-137 in the irradiation of dried sewage solids.

## FLIGHT SYSTEMS DEVELOPMENT

This element consists of the design, development, qualification and fabrication of flight qualified generators.

Key accomplishments in FY 1981 are to complete the final design of the flight generator unit, fabricate and deliver to NASA the power system mass models, and fabricate, assemble, and test the electrically heated engineering generator.

Milestones for FY 1982 are to initiate and complete the qualification level testing of the advanced isotope generator system of the type to be used on both the NASA Galileo and the International Solar Polar spacecraft. The NASA Galileo spacecraft will require two flight units plus a spare, with each generator delivering over 280 watts of electrical power. The European Space Agency's (ESA) International Solar Polar spacecraft will require one flight unit capable of delivering over 280 watts of electrical power. The ESA spacecraft is currently planned to be launched in 1986. Production of silicon germanium unicouples in support of the flight generators will continue and the first and second flight converters are planned to be assembled at the General Electric Company, Valley Forge, Pennsylvania.

## ISOTOPE FUELS

Both the NASA Galileo and International Solar Polar spacecraft will make use of the advanced isotope generator using the General Purpose Heat Source. This modular heat source unit is composed of four 62.5 watt plutonium-238 pellets encapsulated in iridium. Each generator will require 18 modules.

Key accomplishments in FY 1981 are to manufacture, assemble and test suficient general purpose heat source modules to support the fueling and test of the qualification unit in FY 1982. This includes production of fuel, iridium and graphite components. Also in FY 1981, the key parts of the RTG Assembly and Testing Facility will be completed, thus providing DOE a secure facility for testing of fueled generators. Multi-hundred watt heat source production and component fabrication for the Galileo radioisotope heater units will also be completed.

The Savannah River Plant, Aiken, South Carolina, supplies the necessary encapsulated isotope hardware for the program. Under this element, at the Mound Facility, Miamisburg, Ohio, we also plan to support the assembly of the modules into a heat source, the loading of the heat source into the thermo-electric converters, and the testing of the fueled power unit to either qualification or flight acceptance levels. Both the qualification converter and the first flight converter are planned to be fueled and tested in FY 1982.

## POWER SYSTEMS TECHNOLOGY AND SUPPORT

The Power Systems Technology and Support Program element includes development efforts with the Space Power Advanced Reactor (SPAR) plus essential independent quality assurance, quality control and the technical assessment of the flight systems contractor activities.

Space Nuclear Reactor--The Space Reactor Technology Program in FY 1982 has a request of $1.0 million. Assuming that these funds are obtained, component development efforts would continue at the Los Alamos National Scientific Laboratory. Several units of reactor core heat pipes and reactor fuel material will be fabricated and tested. Also, reactor and shielding designs plus limited irradiation testing would be accomplished. NASA has expressed a strong interest in this space reactor power program as it relates to outer-planet exploration missions forecasted for the end of the century.

Technical Support--In order to continue to assure that the flight isotope generator units will perform flawlessly in space, this element includes the independent quality assurance, quality control activities including on-site inspectors at the contractor's plant. Also included is the independent technical assessment of the power systems contractor's reliability and performance predictions including the preparation of conceptual designs and trade-off studies.

Power Systems Technology--Activities for the development of advanced thermoelectric and heat source materials that might be needed for missions in 1987 and beyond will be terminated in FY 1982.

## SPACE POWER SAFETY

This program element includes the assessments to ensure safe and enviromentally acceptable nuclear power sources that will be flight approved. Safety testing of the General Purpose Heat Source modules for both the NASA Galileo and International Solar Polar missions will be conducted. The updated safety analysis report for the NASA Galileo mission is planned to be completed and reviewed by the Interagency Nuclear Safety Review Panel.

## TERRESTRIAL ISOTOPE APPLICATIONS

This element consists of developing beneficial uses and applications for isotopes readily available from defense nuclear wastes.

Key acomplishments in FY 1981 are: to enter into a cooperative agreement with the City of Albuquerque on the sewage sludge irradiation program; to complete the Wichita, Kansas sludge management study; to publish the Department of Energy's National Seminar report on Sewage Sludge Irradiation; to determine the interests of additional municipalities in incorporating an irradiator in their sludge management activities; to deliver Krypton-85 airfield lights to the Department of Defense; and to complete the compatibility and safety test efforts on the strontium fluoride capsule for electric generator applications.

In FY 1982, we plan to continue the operation of the Sandia Irradiator for Dried Sewage Solids as a prototypical unit to gain as much operating information as possible to support the demonstration phase. Technical transfer liaison will continue only with the City of Albuquerque which has been selected for a full-scale irradiation facility. Agricultural and animal supplemental feeding experiments using disinfected sludge are planned to continue at New Mexico State University. In cooperation with the City of Albuquerque, site specific field plots will be used to assess the public acceptance and economics of recycling the City's sludge.

## ADVANCED SYSTEMS EVALUATION

The Advanced Systems Evaluation Program activities, directed toward the assessment of the development and deployment of conventional, advanced, and specialized nuclear systems for various applications, will be terminated in FY 1982.

The key accomplishments in FY 1981 are to:

- Complete study of a 12-unit nuclear energy center in South Carolina
- Operate an advanced power plant cooling demonstration unit directed at reducing dry cooling costs as much as 50 percent
- Complete update of long-range projections where low water consumptive power plant cooling methods would be required in the U.S.
- Initiate investigation of the feasibility of retrofitting nuclear power plants for cogeneration/district heating
- Complete comprehensive field test at a major power plant complex to validate the models on atmospheric impact of heat and moisture releases.

Mr. VOLKMER. I believe it would be more appropriate if we listened to all the witnesses, and then questioned the full panel at that time.

I believe the next witness is Mr. William Voigt. Sir.

Mr. VOIGT. Mr. Chairman.

Mr. VOLKMER. I believe you have a statement for the record. It will, without objection, be made a part of the record, and you can either read the statement or summarize it.

Mr. VOIGT. I am prepared to summarize it, Mr. Chairman.

I am pleased to discuss the Department of Energy's uranium enrichment activities and uranium resource assessment programs.

The first program I would like to discuss is uranium enrichment activities. The goal of the uranium enrichment activities program is to meet domestic and foreign utility and U.S. Government requirements for uranium enrichment services in the most economical, reliable, safe, and environmentally acceptable manner possible.

Our capacity is planned on the basis of nuclear power forecasts and estimates of separative work requirements which DOE will be supplying.

Every 6 months, the DOE Office of Uranium Resources and Enrichment updates its estimates of nuclear electrical generating capacity that the DOE uranium enrichment complex will need to serve.

Chart 1 summarizes our midrange estimate as of January 1981. We expect this on line nuclear power capacity to increase to 144 gigawatts by 1985, to 191 gigawatts by 1990, and to 231 gigawatts by 1995.

CHART 1

### JANUARY 1981 OURE PROJECTION OF NUCLEAR POWER GROWTH

| END OF YEAR | GIGAWATTS | | |
|---|---|---|---|
| | U.S. | NON-U.S.* | TOTAL |
| 1985 | 93 | 51 | 144 |
| 1990 | 127 | 64 | 191 |
| 1995 | 142 | 89 | 231 |

*SUPPORTED BY DOE ENRICHMENT CAPACITY

These estimates are lower than our June 1980 estimates by 1 gigawatt in 1985, 6 gigawatts by 1990, and 29 gigawatts by 1995.

However, I think it is fair to point out that the change in the nuclear power growth from June 1980 to January of 1981 is significantly smaller than that which occurred in our January 1980 forecast which was provided in last year's testimony and the June 1980 forecast.

The 1981 nuclear power growth estimates reflect our best current judgment. While there is uncertainty in any forecast and this is particularly true for nuclear power growth, we are reasonably confident in this estimate as most of the nuclear generating capacity in the forecast through 1995 is either operating or well under construction.

The annual separative work requirement result of this forecast is 22 million separative work units in 1985, 26 million in 1990 and 35 million in 1995.

These separative work requirements include both civilian and U.S. Government requirements for separative work.

We extensively analyze uranium enrichment services supply and demand, economics and capacity expansion options. From this analysis, a long-term enrichment strategy to achieve program goals is developed.

The strategy recognizes near-term demand reductions as well as longer term demand increases, and seeks to optimize DOE production and expansion capabilities. The long-term enrichment strategy forms the basis for developing the fiscal year 1982 budget.

In the short term, the strategy calls for lowering the operating levels of the gaseous diffusion complex, requiring power purchases below existing contract levels.

Consequently, DOE will have to pay demand charges to its power suppliers if current efforts to negotiate reduced power levels are unsuccessful.

The strategy also calls for the continued design and construction of the gas centrifuge enrichment plant (GCEP) at Portsmouth, Ohio. The GCEP will provide an additional 2.2 million SWU of capacity by 1989.

The three existing diffusion enrichment plants had a capacity before improvement of about 17.2 million SWU per year. We are nearing completion of two construction programs, the Cascade improvement and Cascade uprating programs (CIP/CUP), which will expand the diffusion capacity to 27.3 million SWU per year at full power.

The CIP/CUP is on schedule at the Oak Ridge, Tenn., and Paducah, Ky., plants and will be completed by the end of fiscal year 1981.

A 227-day strike at the Portsmouth plant in 1979 has caused a delay in completion of the CIP/CUP until fiscal year 1983.

Turning now to our production levels, in fiscal year 1981, the three gaseous diffusion plants will operate at an average power level of 2,660 megawatts and production is estimated to be 9.5 million SWU. The 2,660 megawatt operating level is adequate to meet the long-term supply/demand projections, but is below the 3,060 megawatts we are contractually committed to purchase from our three power suppliers.

Consequently, we will be paying demand charges for power not purchased in fiscal year 1981.

Turning now to GCEP, GCEP is making excellent progress and is on schedule with the total estimated cost—adjusted for escalation—holding constant. Project momentum continues to build as the physical construction at the site near Portsmouth, Ohio, becomes highly visible.

Through fiscal year 1981, $984.5 million has been authorized, $951,8 million appropriated, with estimated costs of $691.2 million against a total estimated project cost of $6.4 billion in 1982 dollars.

Production of separative work from the centrifuge plant will begin in 1988 with a capacity of 2.2 million SWU per year available in 1989. Additional production capacity will be added as demand for enrichment services warrants or as dictated by economies resulting from the substitution of gas centrifuge enrichment capacity for the more energy intensive gaseous diffusion process.

For planning purposes, full production from the eight-building plant is scheduled in 1994.

The centrifuge development program continues to provide the base technology for the centrifuge and equipment manufacturers of the GCEP. Design qualification tests for the baseline centrifuge are underway as are the long-term reliability tests.

An advance gas centrifuge development program has been initiated which will substantially reduce the cost of enrichment beginning in the late 1980's.

The advanced centrifuge program entails three generations of improved performance: that is, 50, 75 and 100 percent improvements over the baseline machines.

When the decision is made to build capacity beyond 2.2 million SWU, the 50 percent improved centrifuge will be installed in the third GCEP process building.

Subsequently, it will be retrofitted into the first two process buildings.

I think it is fair to say excellent progress has been made during the first 6 months on development of the 50 percent improved centrifuge.

Turning now to our competitive position vis-a-vis the foreign market, in the past several years, we have experienced a sharp decline in our share of the non-U.S. market.

Some foreign customers have already switched from DOE to EURODIF, URENCO, and the Soviet Union, and some new business is expected to go to the non-U.S. suppliers.

This is of concern to us and we need to reverse this trend. Our competitors have an edge in that they are able to offer a variable contract with price, quantity, timing, and reprocessed feed flexibilities.

For the United States to maintain its position as a major supplier to the non-U.S. market and as the sole supplier for the U.S. enrichment market, we must operate existing enrichment facilities efficiently, undertake a timely expansion of DOE enrichment facilities, and at the same time, actively contract and market if we are to compete with other suppliers for international customers.

We currently have a significant price advantage over our competitors. The U.S. price is at $110 per SWU while the standard price of EURODIF and URENCO is about $170 to $180 per SWU.

I would now like to briefly discuss our fiscal year 1982 budget request.

In fiscal year 1982, about $2 billion in authorizations, $1.9 billion in appropriations offset by $1.8 billion in revenues, are requested.

Chart 5 shows that revenues are available to finance approximately 96 percent of our proposed budget, leaving a net appropriation request of $68 million for fiscal year 1982.

CHART 5

## FY 1982 CONGRESSIONAL BUDGET REQUEST
## URANIUM ENRICHMENT ACTIVITIES

| | BUDGET AUTHORITY (DOLLARS IN THOUSANDS) | |
|---|---|---|
| | FY 1981 | FY 1982 |
| **GASEOUS DIFFUSION OPERATIONS & SUPPORT** | | |
| CASCADE POWER | $ 604,000 | $ 802,000 |
| DIFFUSION OPERATIONS | 155,713 | 134,700*** |
| PROCESS & LONG-RANGE TECHNICAL SUPPORT | 14,500 | 17,075 |
| SUPPORTING SERVICES | 73,213* | 25,125 |
| PLANT & CAPITAL EQUIPMENT | 107,000 | 131,200 |
| TOTAL GASEOUS DIFFUSION | 954,426 | 1,110,100 |
| **GAS CENTRIFUGE OPERATIONS & SUPPORT** | | |
| GAS CENTRIFUGE PROCESS DEVELOPMENT & DEMONSTRATION | 64,000 | 76,000 |
| SUPPORTING SERVICES | 800 | 5,200 |
| PLANT & CAPITAL EQUIPMENT | 152,515 | 678,600 |
| TOTAL GAS CENTRIFUGE | 217,315 | 759,800 |
| **PROGRAM DIRECTION** | 3,077** | 3,100 |
| **REVENUES** | −1,254,045 | −1,805,000 |
| TOTAL | $ −79,227 | $ 68,000 |

* REFLECTS $50,000,000 RESTORATION OF CONTRACTOR PREFINANCING AS PROVIDED IN THE FY 1981 APPROPRIATIONS

** INCLUDES $17,000 FOR PAY COST SUPPLEMENTAL

*** EXCLUDES $20,000,000 TO BE FUNDED FROM EXCESS CIP/CUP CONTINGENCY

The major changes in the fiscal year 1982 budget are associated with three principal items.

First, the cascade power request of $802 million represents an increase of $198 million over the fiscal year 1981 budget. This increase is caused by the cost of power purchased and demand payments.

The fiscal year 1982 power purchases are consistent with long-term supply/demand projections. However, these levels are still substantially below the levels we are contractually committed to purchase under the existing contracts with our three suppliers.

If DOE were to purchase power at contractually committed levels, power costs would increase by $584 million over the projected fiscal year 1982 power purchase level.

By not taking the contractually committed level of power, we are required to pay a demand payment of $206 million. Based on negotiations to date and recognizing the excess power supply situation in both the Tennessee Valley Authority (TVA) and Electric Energy, Inc. (EEI) service areas, the fiscal year 1982 budget includes $133 million in demand payments for TVA and $21 million in demand payments for EEI.

Anticipating continued successful negotiations with Ohio Valley Electric Co. (OVEC), which supplies power to our Portsmouth plant, only $12 million of the $52 million OVEC demand charges have been included in this budget.

We are continuing discussions with power suppliers in an attempt to reduce the demand payments.

As in the past, the success of these negotiations depends on the ability of our power suppliers to transfer DOE contract power not purchased to other customers.

The fiscal year 1982 budget assumes the unit cost of power, including demand charges, will increase about 27 percent in fiscal year 1982.

The second major change is the increase in funds to continue the GCEP construction on its current schedule. Finally, the revenue estimate for fiscal year 1982 is about $550 million higher than fiscal year 1981, reflecting an increase in SWU sales and higher prices.

An in-depth discussion of the fiscal year 1982 budget request for the uranium enrichment activities program is contained in the detailed statement submitted for the record.

Turning now to the other area of my responsibility, the uranium resource assessment program. The goals of the uranium resource assessment program have been to assess and expand the nuclear fuel resource base of the United States; reduce uncertainties about the extent, availability, and economics of domestic and foreign nuclear fuel resources; and make available to industry resource information for use in the discovery and production of uranium resources.

The fiscal year 1982 budget—chart 6—will limit the goals of the program to assessing the nuclear fuel resource base of the United States and further reducing uncertainties about the extent, availability, and economics of domestic nuclear fuel resources.

CHART 6

## FY 1982 CONGRESSIONAL BUDGET REQUEST
## URANIUM RESOURCE ASSESSMENT

|  | BUDGET AUTHORITY (DOLLARS IN THOUSANDS) |  |
|---|---|---|
|  | FY 1981 | FY 1982 |
| OPERATING EXPENSES: |  |  |
| ASSESSMENT PROGRAM | $24,625 | $5,500 |
| RESOURCE INVESTIGATIONS | 16,325 |  |
| TECHNOLOGY APPLICATIONS | 3,800 |  |
| SUPPORTING SERVICES | 4,000 |  |
| INTERNATIONAL ACTIVITIES | 500 |  |
| PROGRAM DIRECTION | 4,830 | 4,200 |
| TOTAL OPERATING EXPENSES | 29,455 | 9,700 |
| CAPITAL EQUIPMENT | 500 | 200 |
| PLANT | 800 | 100 |
| TOTAL URANIUM RESOURCE ASSESSMENT | $30,755 | $10,000 |

Essentially, the program will be conducted as it had been from the early 1950's to 1974. Resource estimates and supply analysis will be made in and proximate to uranium districts using company confidential data voluntarily supplied by the uranium industry.

All NURE activities will be terminated, but efforts will be made to utilize data already collected.

The fiscal year 1982 budget request includes $10 million for resource assessment activities. Fiscal year 1982 royalty revenues will be $7.7 million. These funds will be returned to the U.S. Treasury.

In October 1980, "An Assessment Report on Uranium in the United States" was published.

The results of the 1980 resource assessment have been such that we are now estimating resources of 3.485 million tons of uranium through at least the $50-per-pound category

This $50 per pound equates to a price of about $75, which is still economic for nuclear power as contrasted to, say, coal.

As part of our resource studies, land status has been considered to provide an indication of resource availability. We estimate that currently some 95 percent of the resources are on lands available for exploration and production.

However, in recent years, certain States have been investigating the possibilities of restricting access to lands for uranium exploration, and legislation is pending on this now.

This land availability issue affects other minerals and commodities as well, and the administration will be considering policies to insure adequate lands availability for energy and minerals production.

Turning now to the status of the domestic uranium industry, an ongoing part of the program is the monitoring of the state of the industry with particular regard to the impact of uranium imports.

Last fall, Senator Domenici of New Mexico requested that DOE review and report on the impacts of foreign uranium on the U.S. uranium mining industry.

Our findings for this study indicate that the industry is currently viable. Uranium concentrate production in 1980 was at a record high level.

However, there have been cutbacks in both 1979 and 1980 exploration and ore production and hence in employment.

These actions have been the consequence of falling prices and lack of uranium buying activity, a reflection of the domestic near-term oversupply situation.

This situation is principally caused by reactor delays and cancellations, and the lack of new reactor orders, rather than loss of market to foreign uranium.

Actual use of foreign uranium in the United States has been limited. In 1980, some 6.3 percent of the feed delivered to DOE was of foreign origin, compared to the allowable 30 percent.

Domestic utilities have strongly preferred the security offered by use of domestic suppliers. For the next 4 or 5 years, the need for additional uranium in the United States is very limited.

Thus, a possible longer-term problem does exist, depending on U.S. buyer policies and further Government policies toward imports of lower-cost foreign uranium.

The situation will require continuous monitoring to assess the health of the uranium-producing industry, and buyer procurement policy, and we intend to monitor the market closely.

This concludes my statement, Madam Chairman, and members of the committee. I would be happy at this time to answer any questions.

[The prepared statement of Mr. Voigt follows:]

Statement of
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Madam Chairman and Members of the Committee, I am pleased to discuss the Department of Energy's (DOE) Uranium Enrichment Activities and Uranium Resource Assessment programs.

## URANIUM ENRICHMENT ACTIVITIES

The goal of the uranium enrichment activities program is to meet domestic and foreign utility and United States Government requirements for uranium enrichment services in the most economical, reliable, safe and environmentally acceptable manner possible.

Uranium as found in nature contains about seven-tenths of one percent uranium-235 (U-235) which is fissionable. The remainder is essentially uranium-238 (U-238) which is non-fissionable. The fissionable characteristics of U-235 make it desirable to enhance its concentration for use as nuclear fuel. Light water reactors typically require U-235 concentrations in the two to four percent range.

The DOE presently enriches uranium to the desired U-235 product assay levels in its gaseous diffusion plants located at Oak Ridge, Tennessee; Portsmouth, Ohio; and Paducah, Kentucky. These plants were built in the 1940's and 1950's and were operated initially to satisfy defense requirements for enriched uranium. They are now operated primarily to provide enrichment services to domestic and non-U.S. utility customers. In these plants, DOE enriches customer-provided natural uranium in the U-235 component for a fee which recovers the cost of providing the services.

With that as background, I would like next to discuss our current nuclear power forecast and the estimated separative work requirements which DOE will be supplying.

## PROJECTION OF CIVILIAN NUCLEAR POWER GROWTH

Every six months the DOE Office of Uranium Resources and Enrichment updates its estimates of nuclear electrical generating capacity that the DOE uranium enrichment complex will need to serve. Chart 1 summarizes our mid-range estimate as of January 1981. As indicated on the chart, we expect this on-line nuclear power capacity to increase to 144 gigawatts by 1985, to 191 gigawatts by 1990, and to 231 gigawatts by 1995. These estimates are lower than our June 1980 estimates by 1 gigawatt in 1985, 6 gigawatts in 1990 and 29 gigawatts in 1995. These lowered expectations reflect delay and/or cancellation of nuclear power plant construction by some domestic utilities, anticipated additional contract terminations by some non-U.S. customers and a generally less optimistic view of potential new contracts from non-U.S. customers.

The change in our nuclear power growth estimates from June 1980 to January 1981 is significantly smaller than that which occurred from our January 1980 forecast provided in last year's testimony and the June 1980 forecast. By contrast the June 1980 estimate was lower than the January 1980 estimate by 16 gigawatts in 1985, 30 gigawatts in 1990 and 34 gigawatts in 1995. These separative work requirements include both civilian and U.S. Government requirements for separative work.

The January 1981 nuclear power growth estimates reflect our best current judgement. While there is uncertainty in any forecast and this is particularly true for nuclear power growth, we are reasonably confident in this estimate as most of the nuclear generating capacity in the forecast through 1995 is either operating or well under construction. Also, recent mid-range forecasts prepared by the Energy Information Administration as well as at least one nuclear industry association are also very similar.

The domestic forecast is based on a detailed examination of each reactor now in the pipeline; that is, planned, ordered, under construction, or operating. We considered such factors as the current construction and licensing status, the length of time that would be needed to complete the project based on Nuclear Regulatory Commission historical data, and financial, environmental and load-growth considerations. The last three factors are based on data included in the enrichment contracts, utility announcements, data from the DOE Energy Information Administration, industry consultants, and media information. The estimates of non-U.S. nuclear power growth were derived in a analogous manner. An assessment was also made on the likelihood of current customers remaining with the U.S.

## REQUIREMENTS FOR DOE ENRICHMENT SERVICES

Chart 2 shows our current projection of annual enrichment services requirements of 22 million separative work units (SWU) by 1985; 26 million SWU by 1990; and 35 million SWU by 1995. The civilian requirements are based on contract data and standardized boiling water and pressurized water once through cycle reactor models and reflect customer plans to go to longer fuel cycles.

U.S. Government needs are also included in the totals. They reflect the most current estimates from the Office of the Assistant Secretary for Defense Programs, the needs for Naval Reactors and for research and development programs.

DOE extensively analyzes uranium enrichment services supply and demand, economics and capacity expansion options. From this analysis a long-term enrichment strategy to achieve program goals is developed. The strategy recognizes near-term demand reductions as well as longer-term demand increases, and seeks to optimize DOE production and expansion capabilities. The long-term enrichment strategy forms the basis of the FY 1982 budget.

In the short-term the strategy calls for lowering the operating levels of the gaseous diffusion complex, requiring power purchases below existing contract levels. Consequently, DOE will have to pay demand charges to its power suppliers if current efforts to negotiate reduced power levels are unsuccessful. In FY 1982 the complex will operate at the same power levels as in FY 1981. These levels represent an acceptable level of risk of equipment failures from prolonged operations below plant design levels.

The strategy also calls for the continued design and construction of the Gas Centrifuge Enrichment Plant (GCEP) at Portsmouth, Ohio. The GCEP will provide an additional 2.2 million SWU of capacity by 1989. GCEP can be completed by adding capacity in blocks of 1.1 million SWU sequentially as dictated by demand up to a total of 8.8 million SWU. Completion of the full GCEP is currently projected for 1994. This is the same schedule as was presented in the FY 1981 budget.

## GASEOUS DIFFUSION PROCESS

Chart 3 depicts the separation of the two principal isotopes, U-235 and U-238 by the gaseous diffusion process. When uranium hexafluoride gas ($UF_6$) is subjected to a given temperature and pressure, the molecules of the lighter gas (U-235) move, on the average, faster than those of the heavier gas (U-238). Thus, the U-235 molecules will pass through a uniquely porous barrier more often than the heavier U-238 molecules. With each pass across the barrier, the $UF_6$ becomes very slightly richer in the U-235 isotope. To obtain the enrichment useful for use in nuclear power reactors, about 1,200 of these passes are required.

The three gaseous diffusion enrichment plants had a capacity before improvement of about 17.2 million SWU. We are nearing completion of two construction programs, the Cascade Improvement and Cascade Uprating Programs (CIP/CUP), which will expand the gaseous diffusion capacity to 27.3 million SWU. The CIP/CUP is on schedule at the Oak Ridge, Tennessee and Paducah, Kentucky plants and will be completed by the end of FY 1981. A 227-day strike at the Portsmouth plant in 1979 has caused a delay in completion of the CIP/CUP until FY 1983. By the end of FY 1981, 9.7 million SWU of the 10.1 million SWU capacity target for CIP/CUP will be installed.

## PRODUCTION

In FY 1981 the three gaseous diffusion plants will operate at an average power level of 2,660 megawatts and production is estimated to be 9.5 million SWU. The 2,660 megawatts operating level is adequate to meet the long-term supply/demand projections; but is below the 3,060 megawatts we are contractually committed to purchase from our three power suppliers. Consequently, we will be paying demand charges for power not purchased in FY 1981. This will be discussed in more detail later in my testimony.

## GAS CENTRIFUGE PROCESS

The principles of a gas centrifuge process are illustrated in Chart 4. A centrifuge is a cylinder which rotates at a high speed in order to separate two components by centrifugal force. The degree of enrichment in a single centrifuge depends on the mass difference of the isotopes being separated, the lengths of the rotor, and most importantly, the speed of rotation. Gas centrifuge technology has been under development since the early 1960's and led to the development of the gas centrifuge machine that will be utilized in the GCEP.

## PORTSMOUTH GAS CENTRIFUGE ENRICHMENT PLANT

GCEP is making excellent progress and is on schedule with the total estimated cost (adjusted for escalation) holding constant. Project momentum continues to build as the physical construction at the site near Portsmouth, Ohio becomes highly visible. Process Building No. 1 is closed in, the floor modules for the centrifuge machines are being installed, and contracts have been let for the process piping, electrical, heating and ventilation systems. Site preparation and rough grading for all eight process buildings is complete. The fire station, central receiving warehouse, mobile equipment garage and several supporting facilities are finished. Work is underway on the Recycle Assembly building, the electrical substations, the water plant, the process support building and the administration building. Through FY 1981, $984,520,000 has been authorized, $951,845,000 appropriated, with estimated costs of $691,234,000 against a total estimated project cost of $6,400,000,000 in 1982 dollars. Twenty-one (21) major construction contracts have been completed and 17 are underway. Design of the entire complex is over 60% complete with six (6) of the nine (9) major architect engineers having essentially finished their design efforts. Three centrifuge machine manufacturers are under contract and are constructing manufacturing facilities in Ohio and Tennessee. All of the centrifuge manufacturing facilities will be operating in 1981.

The initial section of the first process building, called the "early train" is scheduled to be on line in 1985. This will provide the first large-scale operation of commercially mass-produced centrifuges. The "early train" machines will allow DOE to verify and qualify the manufacturing and assembly process before tens of thousands of centrifuges are required for the rest of the plant. The U.S. gas centrifuge process being used for GCEP is the world's most advanced. It consumes only 5 percent of the electric power needed for production of an equivalent amount of uranium enrichment using the existing gaseous diffusion process.

Production of separative work from the centrifuge plant will begin in 1988 with a capacity of 2.2 million SWU per year available in 1989. Additional production capacity will be added as demand for enrichment services warrants or as dictated by economies resulting from the substitution of gas centrifuge enrichment capacity for the more energy intensive gaseous diffusion process. For planning purposes, full production from the 8-building plant is scheduled in 1994.

The centrifuge development program continues to provide the base technology for the centrifuge and equipment manufacturers of the GCEP. Design qualification tests for the baseline centrifuge are underway as are the long term reliability tests. Baseline centrifuges are machines which will be installed in the first two Process Buildings (2.2 million SWU). An Advanced Gas Centrifuge Development Program has been initiated which will substantially reduce the cost of enrichment in the late eighties. The Advanced Centrifuge Program entails three generations of improved performance: 50, 75 and 100 percent improvements over the baseline GCEP centrifuge. When the decision is made to build capacity beyond 2.2 million SWU, the 50 percent improved centrifuge will be installed in the third GCEP Process Building. Subsequently it will be retrofitted into the first two Process Buildings. The 75 and 100 percent improved machines will be available in 1993 and 1998, respectively, for possible retrofit into the GCEP. Excellent progress has been made during the first six months on development of the 50 percent improved centrifuge. Machines have been operated at the new target speed and internal flow efficiency improvement tests are underway. Results to date reinforce our high confidence that the 50 percent improved performance can be achieved on schedule.

## U.S. COMPETITIVE POSITION

In the past several years we have experienced a sharp decline in our share of the non-U.S. market. Some foreign customers have already switched from DOE to EURODIF, URENCO, and the Soviet Union, and some new business is expected to go to the non-U.S. suppliers. This is of concern to us and we need to reverse this trend. Our competitors have an edge in that they are able to offer a variable contract with price, quantity, timing, and reprocessed feed flexibilities. To date we have not been able to offer contracts on this basis due to the non-discriminatory requirements legislated in Section 161V of the Atomic Energy Act of 1954, as amended.

For the United States to maintain its position as a major supplier to the non-U.S. market and as the sole supplier for the U.S. enrichment market, we must operate existing enrichment facilities efficiently, undertake a timely expansion of DOE enrichment facilities, and at the same time, actively contract and market if we are to compete with other suppliers for international customers. To accomplish this we are:

- maintaining an enrichment contracting posture which reflects customer needs, U.S. policy and current market conditions;

- promoting our service by informing existing and potential customers of DOE enrichment policies, contract terms, etc.;

- conducting marketing missions and participating in conferences to explain the benefits of contracting with DOE as well as to assess potential market opportunities, and

- analyzing market forces, customer needs and supply/demand conditions.

DOE currently has a significant price advantage over our competitors. The U.S. price is at $110 per SWU while the standard price of EURODIF and URENCO is about $170 to $180 per SWU.

With a strong contracting and marketing effort, the U.S. will continue to realize a significant benefit from the uranium enrichment program in terms of balance of payments, domestic employment and contribution to nuclear policies abroad.

Today we see the following non-U.S. suppliers in the international market along with their marketplace service capacity.

## Foreign Sellers of Uranium Enrichment Services and Their Enrichment Capacity

| Supplier | Capacity (Millions of SWU/Yr.) |
|---|---|
| USSR | 3 to 4 available for export now |
| URENCO | 0.4 operating; 2.0 committed; 3.0 possible by 1990 |
| EURODIF | 6.0 operating; 10.8 committed, which should be operating by 1982 |
| COREDIF | no current capacity; 10.0 possible by 1990 |
| Japan | 2.0 possible by 1990 |
| Brazil | no current capacity; 0.2 possible by 1985 |

I would now like to discuss our FY 1982 budget request.

## FY 1982 BUDGET REQUEST

The DOE's FY 1982 budget for the Uranium Enrichment Activities Program is shown in Chart 5 by major program components. In FY 1982, about $1,996,525,000 in authorizations, $1,873,000,000 in appropriations offset by $1,805,000,000 in revenues, are requested. Chart 6 shows that revenues are available to finance approximately 96 percent of our proposed budget, leaving a net appropriation request of $68,000,000 for FY 1982.

The budget for the Uranium Enrichment Activities Program as shown in Chart 7 is described in four major program activities: (1) Gaseous Diffusion Operations and Support; (2) Gas Centrifuge Operations and Support; (3) Program Direction; and (4) Revenues.

## GASEOUS DIFFUSION OPERATIONS AND SUPPORT
## OPERATING EXPENSES

Gaseous Diffusion Operations and Support includes funds required for ongoing operation of the gaseous diffusion plants at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. Funds are included for the purpose of cascade power, diffusion operations, process and long-range technical support, and necessary supporting services.

## CASCADE POWER

The three gaseous diffusion plants will operate at a power level of 2,660 megawatts in FY 1982 and produce about 9.9 million SWU. Although the power levels in FY 1982 are at the same level as FY 1981, production will increase by 0.4 million SWU because of continued progress of the CIP/CUP programs. The FY 1982 operating level is consistent with long-term supply/demand projections, and represents an acceptable risk of process equipment failures from prolonged operations below plant design levels. The FY 1982 budget represents a decrease of $186,000,000 as compared to the Carter FY 1982 budget. This change reflects a decrease in the long-term demand projections.

The 2,660 megawatt power level is substantially below the 5,840 megawatts we are contractually committed to purchase under existing contracts with the three power suppliers. Consequently, we are contractually required to pay about $206,000,000 (Tennessee Valley Authority (TVA) - $133,000,000, Electric Energy, Inc. (EEI) - $21,000,000 and Ohio Valley Electric Company (OVEC) - $52,000,000) in demand payments to our power suppliers in FY 1982 for power under contract that will not be purchased. If DOE purchased 5,840 megawatts, it would have increased the power budget $584,000,000 from $802,000,000 to $1,386,000,000.

We are negotiating with our three suppliers and hope to reduce the $206,000,000 of demand payments. Based on negotiations to date and recognizing the excess power supply situation in TVA and EEI service areas, the FY 1982 budget includes the $133,000,000 in demand payments for TVA and $21,000,000 in demand payments for EEI. Anticipating continued successful negotiations with OVEC, only $12,000,000 of the OVEC demand charges have been included in this budget. We are continuing discussions with the power suppliers in an attempt to reduce the demand payments. As in the past, the success of these negotiations depends on the ability of our power suppliers to transfer DOE contract power not purchased to other customers.

The total FY 1982 cascade power budget, including $166,000,000 in demand payments, is $802,000,000. This is an increase of $198,000,000 over the FY 1981 budget and is caused by increases in the cost of power purchased due to higher coal costs and payment of demand charges. The unit cost of power, including demand charges, is estimated to be about twenty-seven percent (27%) higher in FY 1982 than it was in FY 1981. If demand payments are excluded, the increase in unit cost would be closer to six percent (6%). This increase is lower than those experienced in recent years because the energy cost increases (coal, etc.) are being partially offset by decreases in non-energy costs at EEI and OVEC.

The current power budget for FY 1981 is $604,000,000. This budget was submitted to the Congress as part of the former administration's anti-inflation measures, but it did not include any funds to make demand payments on the assumption that the DOE would be successful in negotiations that were then underway with the power suppliers. Negotiations were successful with EEI and OVEC, but TVA was not able to reduce power to the diffusion plants in a way that would eliminate the TVA demand payments. Thus, we are paying demand charges to TVA in FY 1981. These charges are expected to come to a total of $30,000,000 based on the rate adjustments announced by TVA in September 1980. This deficit can be made up by carrying over into FY 1981 surplus FY 1980 operating expenses (primarily power costs) that underran the Congressional budget total by approximately $21,500,000. The FY 1980 power costs were less than anticipated due to the deferral by TVA of a rate increase, lower than projected EEI and OVEC coal costs, and higher than projected on-stream availability of the EEI and OVEC generating units. If Congress approves, these funds will be combined with capital project underruns and FY 1980 prefinancing funds to offset the $26,000,000 FY 1981 power shortfall. The appropriate Congressional committees will be informed of these proposed adjustments to our FY 1981 budget in separate correspondence.

## DIFFUSION OPERATIONS

Diffusion operations funds provide all non-power costs needed for the day-to-day operation of the gaseous diffusion plants; including employee wages and benefits, plant maintenance and upkeep, utility services such as water, nitrogen, steam and dry air, supplies, purchases of special process spares, and general plant services needed to provide security and to protect the health and safety of employees. The FY 1982 budget request of $154,700,000 is a net decrease of about $1,000,000 from FY 1981. This decrease is due to a $9,700,000 reduction in process spares and barrier material purchases in FY 1982 offset by an increase of $8,700,000 for other diffusion operating costs, primarily the increased cost of employees wages and benefits, maintenance, and safeguards and security. The request of $154,700,000 is offset by prior year funds totaling $20,000,000 ($8,000,000 in the CIP project and $12,000,000 in the CUP project). This offset is possible due to a recently completed in-depth review of the total estimated cost (TEC) for these projects. All procurement has been placed for the two projects, and in addition, both projects will be completed by the end of FY 1981 at Oak Ridge and Paducah. Work at Portsmouth is scheduled to be completed by mid FY 1983. Based on the maturity of these projects $20,000,000 in unused contingency can now be removed from the projects resulting in the decrease in the TEC.

## PROCESS AND LONG RANGE TECHNICAL SUPPORT

The FY 1982 request for process and long range technical support is about $17,000,000. These funds support four major technical support missions:

- Achievement of the CIP/CUP production capacity target goals
- Long-term reliability of the gaseous diffusion complex
- Energy conservation and management
- Response to environmental, health, safety and other policy requirements.

The majority of the FY 1982 effort will be directed toward assuring the long-term reliability, performance and economics of the existing plants at their uprated capacity.

The FY 1982 budget request represents an increase of approximately $2,500,000 above the FY 1981 budget. The increase is the net result of increases of about $2,000,000 for long-term plant reliability technical support and about $2,000,000 for energy conservation and management activities and a reduction in CIP/CUP technical support of $1,500,000.

## SUPPORTING SERVICES

We are requesting approximately $25,000,000 for supporting services in FY 1982. These funds are needed for supporting activities essential to operate the diffusion plants. Included are maintenance of facilities in standby; interplant shipments of enriched uranium and other materials, warehousing of uranium inventories, conceptual design and other engineering studies, and related toll enrichment services to both foreign and domestic customers.

The increase in FY 1982 over FY 1981 of approximately $1,900,000 is needed for placing facilities in standby following completion of the CIP/CUP at Paducah and Oak Ridge, conducting environmental, safety and health tests at the Paducah feed plant, and preparing safety analysis studies for the gaseous diffusion plants.

## PLANT AND CAPITAL EQUIPMENT

Capital equipment funds are needed to replace equipment which has exceeded its useful life and to meet program objectives in a more efficient manner. The $23,600,000 requested in FY 1982 will be used to replace equipment which has become obsolete or equipment where replacement parts are no longer available, and to provide for Automatic Data Processing improvements needed to meet the increased demand for precise data gathering and evaluation in the areas of health, safety, and safeguards and security.

Construction funds totaling $107,600,000 are requested for the gaseous diffusion plants to support on-going operations, to properly maintain the plants, and to comply with environmental and safety standards.

New projects requested for FY 1982 are shown on Chart 8 The first item, General Plant Projects, provides funding for projects, costing under $1,000,000, needed to maintain the enrichment facilities, to adapt the facilities for improved production techniques, to improve operational economy and to store depleted $UF_6$ (tails), a byproduct of gaseous diffusion plants operations, in a safe and environmentally acceptable way. be required, specific FY 1982 projects cannot be accurately defined in detail.

The $UF_6$ Cylinders and Storage Yards project is an annual project to provide $UF_6$ cylinders and required storage yards to store depleted $UF_6$ (tails), a byproduct of gaseous diffusion plants operations, in a safe and environmentally acceptable way.

Cooling Tower Modifications are needed at the Oak Ridge and Portsmouth plants. At Oak Ridge a portion of one cooling tower will be rebuilt and at Portsmouth two cooling towers will be rebuilt. This work will restore the cooling capacity of these towers needed at planned operating levels, and to correct the potentially unsafe conditions of the Oak Ridge tower work areas.

The next project, Improved $UF_6$ Containment, will replace the remaining outdated steam chests and low pressure autoclaves with more positive containment-type autoclaves, install double hook cranes to facilitate safe movement of liquid $UF_6$ cylinders, and improve $UF_6$ process piping systems. The project is needed to minimize the likelihood of major $UF_6$ releases, limit the probability of minor releases, reduce the environmental complications associated with $UF_6$ release and minimize the loss of material. This project will provide a safer, more efficient operation and significantly reduce the chances of releasing $UF_6$ to the environment.

Purge and Cascade Withdrawal Modifications will be made at the Paducah plant to provide the operational reliability required of these vital systems in sustaining normal cascade operations. The modifications will incorporate current technology to realize greater operational efficiencies, to conserve energy, and to meet environmental considerations.

The Fire Alarm System Replacement project will restore reliability to a system that is experiencing false and unintelligible alarms. The existing obsolete alarm systems at the diffusion plants will be replaced with modern equipment needed to comply with National Fire Protection Association (NFPA) standards for improved-risk criteria. The new systems will require considerably less maintenance and repair as well as measurably reduce the risk of a fire in the gaseous diffusion plants.

Environmental Protection and Safety Modifications, Phase II, is the second in a series of projects needed to bring the gaseous diffusion plants into compliance with Federal, State and local pollution control standards. The projects will provide compliance with the water pollution and solid waste disposal laws and provide facilities to aid in the control of the accidental release of hazardous materials.

The final project, Air Distribution System Upgrading will improve the mechanical reliability and operational efficiency of the 30-year old compressed air system at the Paducah plant. The improvements are essential to assure the required compressed air capacity necessary for normal cascade operation.

## GAS CENTRIFUGE OPERATIONS AND SUPPORT

### OPERATING EXPENSES

Funds requested for gas centrifuge operations support the continued development and demonstation of the "baseline" centrifuge and "balance-of-plant" equipment to be installed in the first two GCEP process buildings. Gas centrifuge operations funds also support development and demonstration of advanced centrifuges for initial installation in process buildings 3-8 and for replacement machines in process buildings 1 and 2. Of approximately $76,000,000 requested for this activity in FY 1982 approximately half will be expended to operate development and demonstration facilities.

Multiple centrifuges will be operated in cascade to verify the inter-centrifuge and centrifuge to plant interfaces. Valves, feed and withdrawal equipment and recycle and assembly equipment will be tested to verify the balance-of-plant designs. The baseline centrifuge effort will yield a qualified design in FY 1981 for use in the first two process buildings of the GCEP. Long-term reliability testing of this design will continue through FY 1982. With the start-up of the Centrifuge Plant Demonstration Facility (CPDF) in 1982, the baseline centrifuge activities will peak, and emphasis will be shifted toward the Advanced Gas Centrifuge Development Program. Preliminary designs for the first generation advanced centrifuge, which will yield 50 percent more performance than the baseline GCEP machine, will be tested in the Technology Test Facility at Oak Ridge.

The budget also includes the necessary supporting services funds to proceed with operational startup plans and procedures that must be completed to support operation of the first production units of the GCEP. The first centrifuge to operate is scheduled to be installed in process building 1 in January 1985 and the first train of centrifuges is expected to be placed on stream by September 1985. The FY 1982 budget also requests $5,200,000 to support the GCEP startup schedule. The higher funding levels permits the staffing levels to increase from 22 in FY 1981 to 61 in FY 1982. The staffing increase is necessary to formulate the advanced cadre of operators and supervisors that will be involved in startup training activities. This training will be conducted during the CPDF startup and will provide valuable startup and operating experience with production model machines operating in a centrifuge cascade. In addition, the funds required will provide for the development of detailed startup procedures, operational manuals and safety procedures necessary for operation.

## PLANT AND CAPITAL EQUIPMENT

Chart 9 shows the plant and capital equipment funds requested in the FY 1982 budget for Gas Centrifuge Operations and Support.

In FY 1982, $636,325,000 in authorizations and $669,000,000 in Budget Authority is requested for the Gas Centrifuge Enrichment Plant, project 76-8-g. This authority will provide for continuation of engineering, technical support, procurement, and construction activities.

These activities support the project milestones for initial enriched uranium production in 1988, increasing to 2.2 million SWU per year in 1989 with the completion of the first two process buildings.

The construction of GCEP, authorized in FY 1976, will provide the capacity to meet the demand for uranium enrichment services in an efficient manner. It also provides the only basis for signing new uranium enrichment contracts. This ability to contract with the foreign and domestic utilities is necessary to maintain a U.S. position as a major world supplier of uranium enrichment services.

The forecasts of nuclear power growth support the need for additional enrichment capacity in the 1990's, exceeding the capacity of the first two GCEP process buildings. The Uranium Enrichment Strategy Study, completed in October 1980, examined various options to satisfy the forecasted enrichment demand. These options included varying gaseous diffusion plant power levels, introducting Advance Isotope Separation technologies, adjusting uranium feed requirements and inventory management. Based on an evaluation of major factors including cost, viability, and risk, the study concluded that construction of GCEP should be continued on the current schedule.

This conclusion is further reinforced by additional considerations including project momentum, program assurance, and technology potential. By the end of FY 1981, the U.S. will have nearly $1,000,000,000 committed to the project. U.S. industry will also have committed a substantial amount on new facilities, located in many areas of the U.S., to produce components under contracts which have been awarded. The completion of the initial two process buildings represents only a 6 percent increase in U.S. enrichment capacity. Considering the demand situation, this increase is a relatively modest but prudent insurance policy. By establishing the industrial capability and demonstrating the performance of this first production capability, the U.S. will have furthered its technology edge, improved its competitiveness, and established a solid basis to respond to increases for utility demand or to respond to defense requirements. Progress in the development of advanced gas centrifuge models has established confidence that centrifuges with 50 percent higher production capacity can be introduced early into GCEP operations. This introduction will substantially increase capacity and further reduce the unit cost of production.

A continuing commitment to the early completion of the first two process buildings and development of the advanced centrifuge is supported by analysis and recommendations by two independent groups: (1) The Energy Research Advisory Board Study Group on Advanced Isotope Separation, and (2) The Uranium Enrichment Management Review Team.

Conservation and economic factors also continue to support the construction of GCEP. The gas centrifuge technology was selected rather than gaseous diffusion because of its lower cost of production and the fact that it uses only 5 percent of the electrical power required for diffusion operation. These same criteria may provide the basis for considering the displacement of gaseous diffusion operation by constructing gas centrifuge enrichment capacity. The analysis shows that over the life of GCEP the reduction in electrical power consumption is the equivalent of 1.5 billion barrels of oil. This equates to 150 thousand barrels of oil per day at the plant-equilibrium operation, therefore, providing a major energy conservation opportunity. This conservation also will avoid the need for over 3,000 megawatts of new electrical generating capacity at a capital cost of $3,500,000,000 to the U.S. economy.

In looking at the economics of gaseous diffusion and gas centrifuge production, one must view the cost on an incremental basis. For gaseous diffusion plants, incremental cost is the operating cost (primarily power). For the GCEP, incremental cost includes the operating cost (primarily labor and materials) and the uncommitted capital costs.

In FY 1982 dollars, the incremental unit cost of production from GCEP (8 process buildings) is substantially less than the incremental cost for existing gaseous diffusion plants. Furthermore, the incremental unit-cost of production from the GCEP first two process buildings is competitive with the cost of comparable gaseous diffusion production. In other words, the out-of-pocket cost for production from GCEP, even for only two-building production, is competitive with the current out-of-pocket cost of gaseous diffusion production. Assuming that power costs will increase at a higher rate than the general economy, as it has in recent years, the difference in incremental unit cost will widen in favor of GCEP. With or without the higher escalation rate for power, but assuming a continued escalation in all costs the differential will still widen in favor of GCEP because over time more of the GCEP costs are committed and therefore no longer subject to escalation.

Our analysis shows that the incremental cost of the full 8 process building plant is cost competitive with the advanced isotope separation processes when an adjustment is made to reflect the uncertainties of the advanced processes.

FY 1982 GCEP activities have been tailored in scope and schedule to minimize total project costs and year-end uncosted obligations. Procurements have been sized in the smallest possible economical packages. Reductions in the proposed FY 1982 GCEP budget will impact the current project schedule and the total estimated cost of the facility because of delays in the arrival of materials and equipment needed for plant construction.

Construction funds are requested to initiate design and long-lead procurement and construction activities for the Advanced Centrifuge Test Facility (ACTF) in FY 1982, project 82-R-418. This facility will provide for the long-term reliability testing of the first generation advanced gas centrifuge, mentioned earlier.

## PROGRAM DIRECTION

The FY 1982 request also includes funds to cover salaries and related benefits of the DOE Headquarters and field personnel associated with the Uranium Enrichment Activities Program. Funds are included for 63 DOE staff-years for the Headquarters Office of Uranium Resources and Enrichment program management and support, and the Oak Ridge Operations Office for guards.

## REVENUES

Revenues are received from the sale of enrichment services to domestic and non-U.S. customers. For FY 1982 we estimate $1,805,000,000 from the sale and delivery of 13.9 million SWU. The increase of approximately $550,000,000 from FY 1981 results from increased sales and higher prices. As required under law, DOE enrichment service charges are based on cost recovery pricing for all services provided. Also included in the revenue estimate is $52,000,000 from the sale of depleted uranium to Italy. The revenue estimate is $149,000,000 higher than the revenue estimate included in the Carter FY 1982 budget. The higher revenue budget reflects further increases in price resulting primarily from the lower forecast for enrichment services.

## MAJOR STUDIES

Three major studies have recently been completed which impact on the uranium enrichment program: The Uranium Enrichment Strategy Study, the Uranium Enrichment Managerial Review, and an Energy Research Advisory Board Study Group.

## URANIUM ENRICHMENT STRATEGY STUDY

Faced with a continuing trend of decreased demand and fiscal constraints, DOE undertook a major study last spring and summer to evaluate alternative courses for meeting demand in a cost effective and reliable manner. The analysis consisted of three separate studies, each evaluating slightly different but interrelated and complementary enrichment enterprise issues. The results of this effort was a major consideration in preparing our FY 1982 budget request.

One study evaluated the economics of producing enriched uranium for various demand levels over a 30-year period from various combinations of existing gaseous diffusion plants, new plants using gas centrifuge technology now in hand, advanced gas centrifuge technology and/or advanced laser or plasma isotope separation technology.

A second study investigated the feasibility of replacing energy intensive existing gaseous diffusion capacity with gas centrifuge capacity if demand would be reduced sufficiently to permit this. Economics and other factors involved in such replacement were evaluated as well as the sensitivity of the economics to power cost changes and centrifuge technology improvements.

A third study developed operating plans through 1995 which could confidently be projected to meet demand and upon which near term budget decisions could be made. Tradeoffs between near and long term production stockpile levels were evaluated. Criteria used to evaluate these plans included budget impacts, cash flow, cost of enrichment services and flexibility to accommodate changes in demand.

A significant conclusion of analyses was that the current schedule for the initial increments of GCEP should be maintained for the following reasons:

(1) Considerable economic, budgetary, cash flow and other advantages are obtained by reducing near-term gaseous diffusion plant power levels, utilizing existing stockpiles and pursuing GCEP on the current schedule, as compared to deferring capacity expansion and pre-producing from the gaseous diffusion plants.

(2) All reasonable forecasts of nuclear power growth indicate that enrichment capacity greater than the initial increments of GCEP will be needed to sustain contract demands at reasonable tails assay levels in the 1990's as well as serve as a contingency for defense purposes.

(3) GCEP production will be less expensive than the incremental cost of existing gaseous diffusion capacity. Thus, GCEP can replace gaseous diffusion capacity on an economic basis if demand erodes sufficiently to permit this.

(4) Any delay in the schedule of the first two buildings at this time will seriously jeopardize the viability of the GCEP project, as such delay is likely to result in the loss of critical material and centrifuge machine vendors.

(5) Even if the Advanced Isotope Separation processes are highly successful, GCEP production economics over the campaign period are very competitive. Even in the worst case, GCEP provides assurance against uncertain civilian and defense demands at modest cost.

## OPERATING PLAN

The Strategy Study developed two major alternative operating plans. One of the recommended plans in the strategy study permitted power reductions through much of the 15-year campaign period. Except for a power reduction in FY 1982 and a corresponding increase in FY 1986 and small changes in the mid-1990's, the power reduction schedule in that plan is a perfect fit for our most recent forecast. Chart 10 shows the separative work contained in the DOE low enriched uranium stockpile as a function of time for this slightly revised production plan using our most current forecast of requirements. As indicated, we meet all requirements while achieving and maintaining our target minimum inventory of 14 million SWU beginning in the mid-1980's. This plan also permits us to maintain the transaction tails assay at the current 0.20 percent level.

## URANIUM ENRICHMENT MANAGERIAL REVIEW

Recognizing the commercial nature of the enrichment program, the Assistant Secretary for Resource Applications asked a group of experienced business executives to review the operation, financing and management of the uranium enrichment program. The review group was specifically asked to focus on the management activities within the program to which sound business practices could be applied. All recently retired from top-level executive positions, the individuals who agreed to participate in this management review were: Mr. Julian D. Ellett, former general manager, Atomic Energy Division, Petrochemicals Department, E.I. duPont de Nemours and Company; Mr. William B. Rieke, former president, Lockheed Missiles & Space Company; Mr. John W. Simpson, former president, Power Systems, Westinghouse Electric Corporation; and Mr. Paul E. Sullivan, former executive vice president, Bank of America National Trust and Savings Association.

The review group found that the enrichment program was well managed, considering the constraints under which it must operate. They noted that many effective management practices and efforts to improve these practices were being applied. They recommended that DOE:

- Take more aggressive steps to renegotiate contracts for the electric power needed to run the diffusion plants,
- Conduct a more rigorous investigation of the minimum power operating level for the diffusion plants,
- Confirm a full commitment to complete the first two buildings of the gas centrifuge project as fast as economically practicable,
- Give the enrichment program control over the management of the advanced isotope separation research and development program,
- Support legislation to establish a revolving fund,
- Evaluate the practicality of establishing the enrichment enterprise as an independent agency similar to the TVA.

These and other recommendations and the significant findings are presented in their final report, "Uranium Enrichment Management Review", dated December 2, 1980. Copies of this report are available.

## DOE REVIEW OF ADVANCED ENRICHMENT TECHNOLOGIES

During 1980, an Energy Research Advisory Board (ERAB) Study Group was chartered by DOE to review the three AIS techniques being developed by DOE and a private R&D project sponsored by Jersey Nuclear Avco Isotopes (JNAI). The Group was requested to review:

- Overall AIS Program Strategy
- Current technology state of the art

- Future risks, benefits and costs associated with implementation of a particular AIS technology

In addition, the Board reviewed the Advanced Gas Centrifuge program in the context of potential needs and costs for uranium enrichment.

The Board recommended that:

- The AIS program reorganize their activities to concentrate R & D on the key technical uncertainties, leading to a mid-FY 1983 selection of one AIS process for further development.
- A team effort with JNAI, Lawrence Livermore National Laboratory and Union Carbide - Nuclear Division be negotiated by DOE, to strengthen development of one of the competitive AIS processes.
- The 2.2 million SWU increment of the Gas Centrifuge Enrichment Plant be continued.
- The Advanced Gas Centrifuge Development Program be continued, with high priority.
- The AIS program treat, as a central design problem, risks of proliferation as the AIS processes mature.
- All of the advanced uranium enrichment research and development be under the same overall DOE management organization to facilitate the making of long-term decisions.
- Periodic assessment of other isotope separation methods be continued, giving some attention to new technology.

DOE is considering these recommendations.

## URANIUM RESOURCE ASSESSMENT PROGRAM

Uranium is a unique metal. It can be used to make atomic weapons and to fuel power plants. In recognition of this, most governments have paid particular attention to the study and monitoring of uranium resources and production. The function, therefore, has involved indepth study of uranium and has been carried out by those agencies most involved in nuclear energy policy and development. The activities of the Uranium Resource Assessment program began in the days of the Atomic Energy Commission when the work was directed toward the development of uranium supplies urgently needed for defense programs. The activity was carried on by the Energy Research and Development Administration (ERDA) and by DOE. Considerable staff expertise and an extensive body of information have been developed over the years. The need for information to support planning for light water reactors by the utilities and the need for systematic and comprehensive resource information to insure sound energy and nuclear planning have in recent years called for increased emphasis on the long term - beyond the year 2000 - aspects of uranium supply and economics and led to the initiation in 1974 of the National Uranium Resource Evaluation (NURE) program. Much has been accomplished in that phase of work in recent years. Clarification of longer term supply and reduced demand expectations have reduced the need for such information and shifts in the nature of the program are taking place. More emphasis is being given to the firmer near-term reserves and the production and cost outlook.

The goals of the Uranium Resource Assessment program have been to assess and expand the nuclear fuel resource base of the United States; reduce uncertainties about the extent, availability and economics of domestic and foreign nuclear fuel resources; and make available to industry resource information and technology for use in the discovery and production of uranium resources. These goals have been accomplished through estimation of uranium reserves based on proprietary industry data, analysis of uranium supply, assessment of potential uranium resources, development of improved methodology and technology for resource identification and assessment and support of international activities to assess the world uranium resource base.

## ASSESSMENT PROGRAM

The FY 1982 budget request includes $10,000,000 for resource assessment activities (Chart 11). The goals of the program will be limited to assessing the nuclear fuel resource base of the United States and reducing uncertainties about the extent, availability and economics of domestic nuclear fuel resources. The core program of reserve and resource estimation and supply analysis will continue as it had from the early 1950's to 1974. Estimates and analyses will be made in and proximate to uranium districts using company confidential data voluntarily supplied by the uranium industry. All NURE activities designed to increase the data base for resource estimation and to develop, intergrate and apply advanced technologies for resource identification and assessment will be terminated, but efforts will be made to utilize data already collected to supplement the 1983 assessment report on U.S. resources. Technology support will be reduced to maintenance of calibration facilities and in-house activities needed for adequate interpretation of industry data. Limited international cooperative activities will be conducted in-house. The lease administration of DOE-controlled mineral lands will continue. In FY 1982, royalty revenues will be $7,700,000. These funds will be returned to the U.S. Treasury.

## PROGRAM DIRECTION

FY 1982 funds requested for Program Direction will support 80 full time permanent (FTP) positions or 85 full time equivalents. This level is reduced from 90 in FY 1981 and 113 in FY 1980 and is lower than the pre-1974 level of 85 FTP which supported the core program at that time. The core program requires the use of DOE professional geologists and engineers due to the imposition of proprietary restrictions by firms providing the data. It has not been possible to employ contractor personnel in activities involving company proprietary data. Success of the program requires that the confidence of the industry be maintained in this important matter.

## MAJOR ACCOMPLISHMENTS

In October 1980 "An Assessment Report on Uranium in the United States" was published. This was the third major report on uranium resources to be released since the National Uranium Resource Evaluation (NURE) began in 1974. Earlier reports are the NURE Preliminary Report of June 1976 and the NURE Interim Report of June 1979. In addition to these major NURE reports, the U.S. Department of Energy (DOE) also publishes annual reports detailing estimates of domestic uranium reserves and potential resources and other data on a number of aspects of uranium supply and demand.

Of the 621 National Topographic Map Series quadrangles that cover the conterminous 48 states and Alaska, 1980 NURE resource assessments were completed for 135 quadrangles and portions of about 45 others. The areas studied contain most of the areas for which U.S. uranium resource estimates had previously been made, Chart 12. There are other "favorable" areas that have been identified but for which data have been inadequate to make quantitative resource appraisals.

The estimates of uranium resources were developed from an extensive data base accumulated during the last three decades of Government and industry exploration activities, including the extensive NURE program investigations of the past 5 years. This data base developed by the NURE program thru FY 1980 consists of: (1) radiometric logs obtained from hundreds of thousands of industry drill holes; (2) aerial radiometric and magnetic surveys involving over 1,000,000 flight-line miles of data, Charts 13 and 14 ; (3) over seven hundred thousand geochemical samples of stream sediments and surface and ground waters, covering more than 2.4 million square miles, Chart 15 and 16; (4) over 420,000 feet of NURE drilling and coring in 18 project areas providing needed subsurface information in specific favorable uranium environments; and (5) over 2 million feet of spectral radiometric logging on non-uranium industry drilled-holes. To enhance data correlation and evaluation, extensive surface geologic data were compiled.

An improved method for the estimation of potential resources was developed and utilized for the first time in the October 1980 report which provided estimate confidence levels. The geologic analogy probability procedure employed by DOE for estimating potential resources is based fundamentally on the acquisition of appropriate amounts and types of "uranium favorability" data to facilitate objective comparative analysis of the resource areas under study with "control areas" for which extensive detailed information is available. The procedures provide reliability of resource estimates at specific confidence levels, while also making full use of the available geologic information and of the expertise of the estimators in uranium geology and resources. The procedures are standardized to minimize personal biases and documented to facilitate review and revisions as new resource information is acquired.

## RESOURCE ESTIMATES

In the uranium resource classification system used for DOE estimates, reserves are the firmest class of resources, comprising deposits that have been delineated by drilling or other direct sampling methods. Potential resources are the quantities of uranium believed to be present in deposits that are incompletely defined or undiscovered. Potential resources are divided into probable, possible, and speculative classes based on their spatial or geologic relationships to defined resources.

Estimated resources are grouped into selected "cost" (not price) categories of \$15, \$30, \$50, and \$100 per pound of $U_3O_8$ to cover a broad spectrum of economic availability. The applicable costs used to assign the uranium resources to these categories are "forward" costs comprising operating and capital costs, in 1980 dollars, that is the costs yet to be incurred in producing the uranium. The various cost categories are independent of the market price at which the uranium would be sold. The corresponding "price" which would support a 15 percent rate of return would average roughly 1.5 times the forward cost per pound of $U_3O_8$.

The results of the 1980 resource assessment are shown in Chart 17. Resource estimates are presented by resource class and cost category and with three probability distribution values (mean, 95th percentile, and 5th percentile). At the lower cost level of $15 per pound, the mean estimate of reserves is 225,000 tons $U_3O_8$. Probable potential resources, in well-developed mineral trends in and around the current uranium districts, are estimated at 295,000 tons. Possible potential resources in favorable productive areas (ones with 10 tons $U_3O_8$ production or reserves) but out of the delineated mineral trends are 87,000 tons, and speculative potential resources which are in favorable areas that have not been productive to date, are 74,000 tons. The total of reserves and potential at $15 is 681,000 tons. There is judged to be a 95 percent probability that the true estimates are at least 447,000 tons and only a 5 percent probability that they are larger than 1,026,000 tons.

At higher cost levels the size of the resource increases. The total of the means including all classes of resources at $30 costs are 2,187,000 tons; at $50 the total is 3,485,000 tons; and at $100 the total is 4,903,000 tons $U_3O_8$. Current uranium prices are between $25 and $30 per pound. Therefore, resources with costs of $30 or more are not currently economic. However, the higher cost uranium would produce power in light water reactors that is economically competitive with other available and projected electric power sources, so these resources must be considered for longer range planning.

As part of our resource studies, land status has been considered to provide an indication of resource availability. We estimate that currently some 95 percent of the resources are on lands available for exploration and production. However, in recent years, certain states have been investigating the possibilities of restricting access to lands for uranium exploration. Legislation is pending.

## U.S. PRODUCTION CAPABILITY

A study has been conducted on uranium production levels attainable from uranium reserves in the United States and on related costs. Using the "production center" concept, U.S. uranium production capability has been projected from ore reserves estimated as of January 1980, to be available at forward costs of $30 per pound $U_3O_8$ or less. The production centers consist of operating (Class 1), committed (Class 2), or planned (Class 3) uranium extraction and processing facilities. No potential resources were utilized. Seventy production centers have been identified, including conventional mills supplied by open pit and/or underground mines; solution mining and heap leach operations; and operations where uranium is recovered as a byproduct of phosphate, copper, and beryllium mining and processing activities. Many of the production centers include several types of operations.

Projections are based primarily on operating conditions — average ore grades, mill recoveries, and operating and capital costs -- similar to those currently prevalent in the uranium mining and milling industry. Specific information on company plans, costs, and operating methods has been incorporated.

Forward capital and operating costs have been estimated for production from each major uranium deposit (or groups of small deposits) included in a given production center. For existing operations, direct mining and milling costs are included along with applicable on-going development costs.

Chart 18 shows the total projected production capability categorized by forward production costs. Projected uranium demand and current sales commitments are also shown. Domestic demand is based on the DOE's Office of Uranium Resources and Enrichment 1980 mid-case nuclear power growth projection, assuming no reprocessing and a 0.20% U-235 enrichment tails assay. Sales commitments include sales to U.S. and foreign buyers, based on data available as of January 1, 1980.

## STATE OF THE DOMESTIC URANIUM INDUSTRY

An on-going part of the program is the monitoring of the state of the industry with particular regard to the impact of uranium imports. Last Fall, Senator Domenici of New Mexico requested that DOE review and report on the impacts of foreign uranium on the U.S. uranium mining industry.

Restrictions on the enrichment of foreign uranium for domestic end-use are being removed in steps according to a plan announced in 1974 by the Atomic Energy Commission in accordance with Section 161v of the Atomic Energy Act, as amended. The Act provided that "the Commission to the extent necessary to assure the maintenance of a viable domestic industry shall not offer enrichment services for foreign uranium for use within the United States." The Commission's plan, based on an analysis of U.S. and foreign supply and demand outlook, allowed initial use of foreign uranium in 1977 limited to 10 percent of toll enrichment customer's feed deliveries to DOE. The allowable percentages increased to 15 percent in 1978, 20 percent in 1979, 30 percent in 1980, and 40 percent in 1981. The plan increases the percentage to 60 percent in 1982, 80 percent in 1983, and in 1984 there would be no established limit.

As part of the announcement, the plan also stated that "the AEC will monitor the extent of importation of foreign uranium for domestic use and its affect on the domestic producing industry" and, if the "use of foreign uranium should impair or threaten to impair the common defense and security..." "to institute such measures as are deemed necessary." DOE has continued this activity of gathering data on the state of the domestic industry and reliance on foreign uranium. Thus, most of the data needed to review the situation were available to DOE.

In our review, we considered the state of the industry considering resources, exploration activity, current and planned production and trends in employment, productivity, investment and revenues. Also examined were the market outlook, past use of foreign uranium, prices and the foreign supply and demand outlook.

Our findings for this study indicate that the industry is currently viable. Uranium concentrate production in 1980 was at a record high level. However, there have been cutbacks in 1979 and 1980 exploration and ore production and hence in employment. These actions have been the consequence of falling prices and lack of uranium buying activity, a reflection of the domestic near-term over-supply situation. This situation is principally caused by reactor delays and cancellations, and the lack of new reactor orders rather than loss of market to foreign uranium. Actual use of foreign uranium in the U.S. has been limited. In 1980 some 6.3 percent of the feed delivered to DOE was of foreign origin compared to the allowable 30 percent. Utilities have in practice strongly preferred the security offered by use of domestic suppliers. Of the 55 utilities that have contracted for uranium, only 15 have contracted for foreign uranium. For the next four or five years the need for additional uranium in the U.S. is very limited.

There are new low cost foreign production operations, especially in Canada and Australia, that could be very competitive with the U.S. producers. The ones that are committed for construction have sold much of the production to foreign buyers. However, there is a potential for longer range foreign penetration in the U.S. market from additional facilities that could be built. Thus, a possible longer term problem does exist, depending on U.S. buyer policies. The U.S. is currently largely self-sufficient and has the capability of remaining so for quite some time. However, the situation will need continuous monitoring to assess the health of the uranium producing industry, contracting for foreign uranium and foreign supply developments.

## CHART 1

## JANUARY 1981 OURE PROJECTION OF NUCLEAR POWER GROWTH

| END OF YEAR | GIGAWATTS U.S. | NON-U.S.* | TOTAL |
|---|---|---|---|
| 1985 | 93 | 51 | 144 |
| 1990 | 127 | 64 | 191 |
| 1995 | 142 | 89 | 231 |

*SUPPORTED BY DOE ENRICHMENT CAPACITY

## CHART 2

## JANUARY 1981 OURE PROJECTION OF ANNUAL ENRICHMENT REQUIREMENTS

| FISCAL YEAR | MILLIONS OF SWU* |
|---|---|
| 1985 | 22 |
| 1990 | 26 |
| 1995 | 35 |

*AT A 0.20% U-235 TAILS ASSAY

CHART 3

# GASEOUS DIFFUSION STAGE

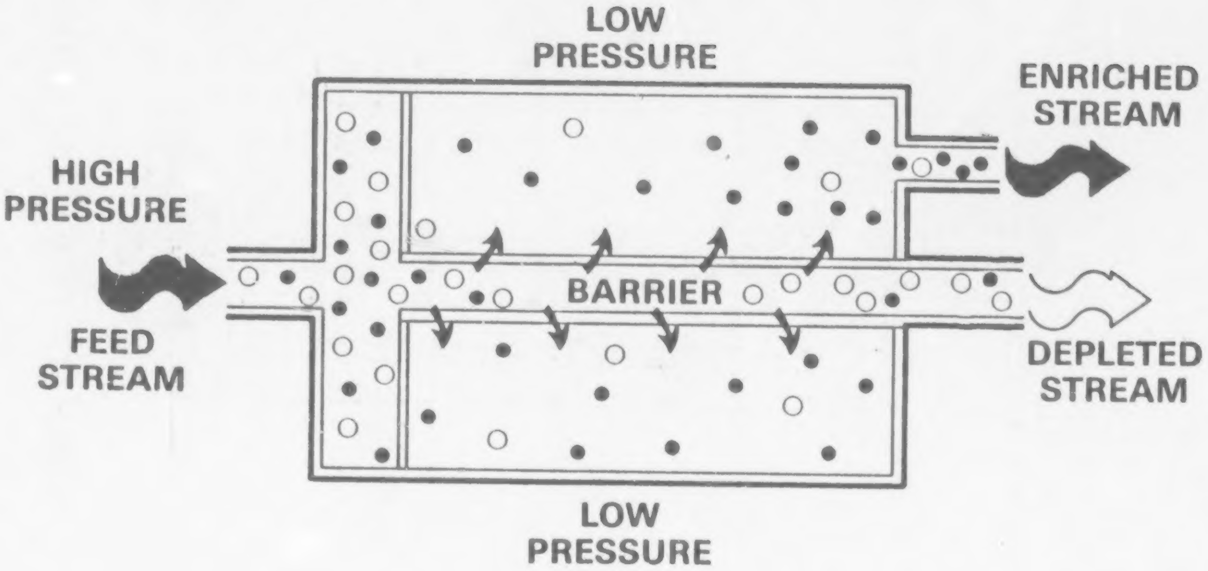
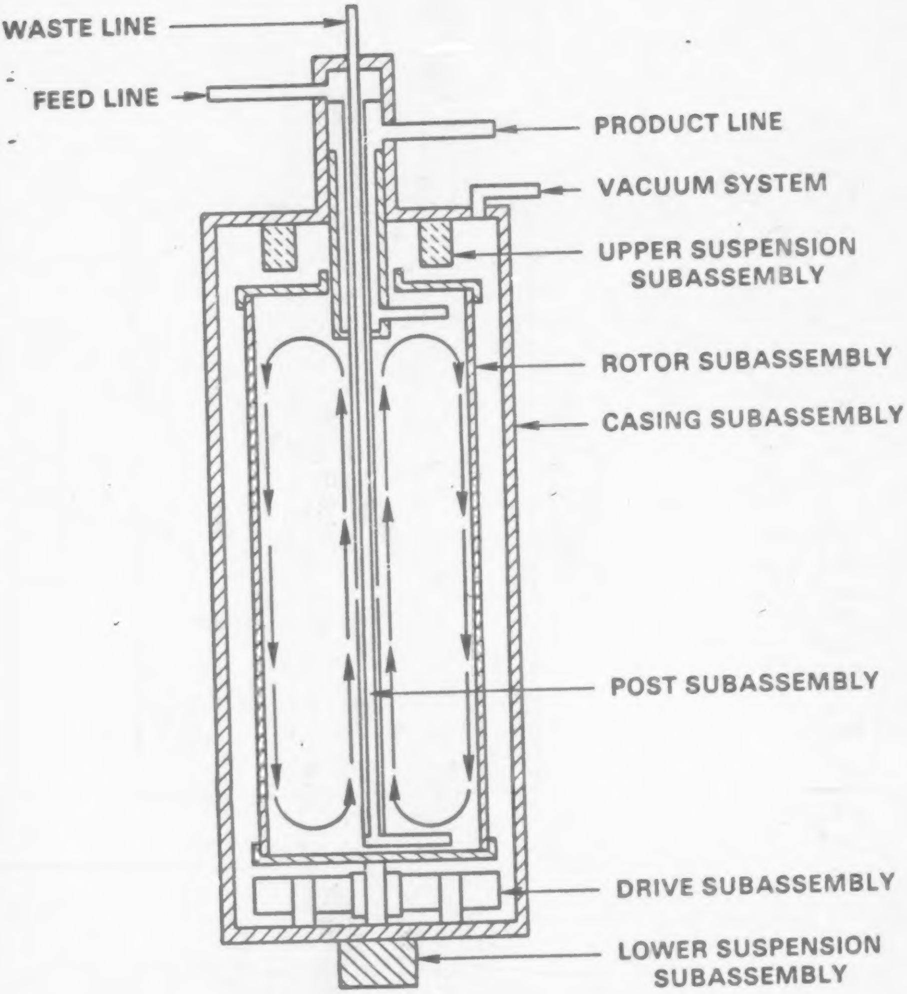

LOW
PRESSURE
ENRICHED
STREAM
HIGH
PRESSURE
BARRIER
FEED
STREAM
DEPLETED
STREAM
LOW
PRESSURE

CHART 4


WASTE LINE
FEED LINE
PRODUCT LINE
VACUUM SYSTEM
UPPER SUSPENSION SUBASSEMBLY
ROTOR SUBASSEMBLY
CASING SUBASSEMBLY
POST SUBASSEMBLY
DRIVE SUBASSEMBLY
LOWER SUSPENSION SUBASSEMBLY

SCHEMATIC OF GAS CENTRIFUGE

CHART 5

## URANIUM ENRICHMENT ACTIVITIES

### FY 1982 BUDGET BREAKDOWN

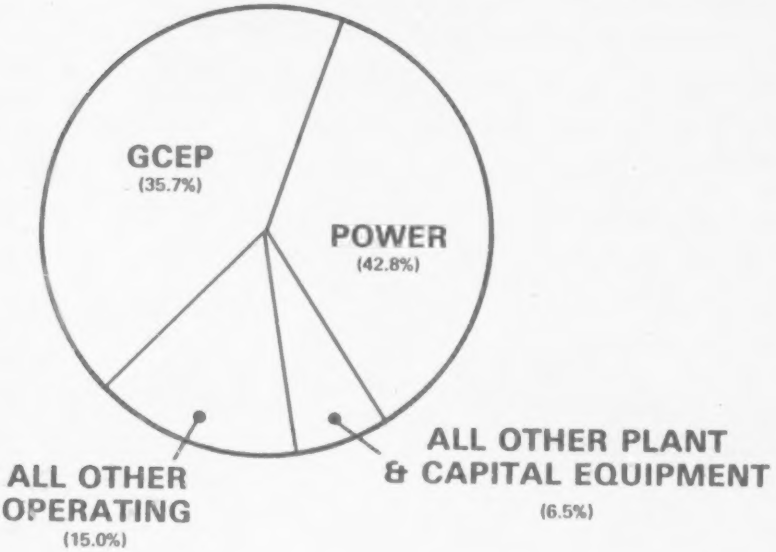
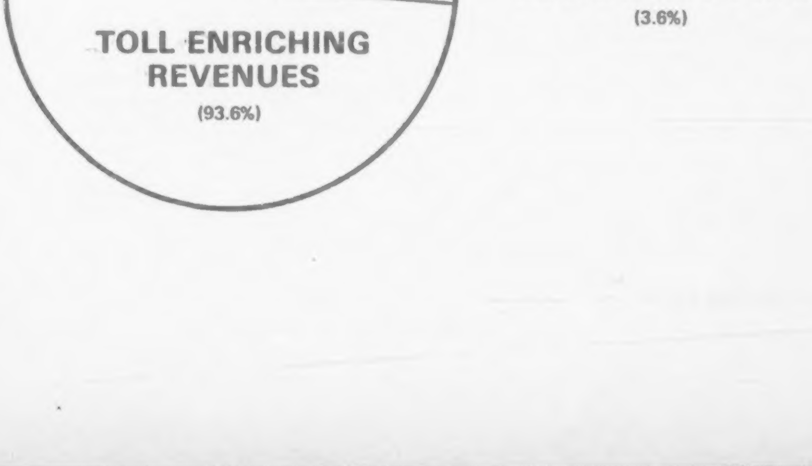


CHART 6

## URANIUM ENRICHMENT ACTIVITIES

### FY 1982 REVENUE BREAKDOWN



## CHART 7

### FY 1982 CONGRESSIONAL BUDGET REQUEST
## URANIUM ENRICHMENT ACTIVITIES

| | BUDGET AUTHORITY (DOLLARS IN THOUSANDS) | |
|---|---|---|
| | FY 1981 | FY 1982 |
| **GASEOUS DIFFUSION OPERATIONS & SUPPORT** | | |
| CASCADE POWER | $ 604,000 | $ 802,000 |
| DIFFUSION OPERATIONS | 155,713 | 134,700*** |
| PROCESS & LONG-RANGE TECHNICAL SUPPORT | 14,500 | 17,075 |
| SUPPORTING SERVICES | 73,213* | 25,125 |
| PLANT & CAPITAL EQUIPMENT | 107,000 | 131,200 |
| TOTAL GASEOUS DIFFUSION | 954,426 | 1,110,100 |
| **GAS CENTRIFUGE OPERATIONS & SUPPORT** | | |
| GAS CENTRIFUGE PROCESS DEVELOPMENT & DEMONSTRATION | 64,000 | 76,000 |
| SUPPORTING SERVICES | 800 | 5,200 |
| PLANT & CAPITAL EQUIPMENT | 152,515 | 678,600 |
| TOTAL GAS CENTRIFUGE | 217,315 | 759,800 |
| **PROGRAM DIRECTION** | 3,077** | 3,100 |
| **REVENUES** | –1,254,045 | –1,805,000 |
| TOTAL | $ –79,227 | $ 68,000 |

* REFLECTS $50,000,000 RESTORATION OF CONTRACTOR PREFINANCING AS PROVIDED IN THE FY 1981 APPROPRIATIONS

** INCLUDES $17,000 FOR PAY COST SUPPLEMENTAL

*** EXCLUDES $20,000,000 TO BE FUNDED FROM EXCESS CIP/CUP CONTINGENCY

## CHART 8

### FY 1982 CONGRESSIONAL BUDGET REQUEST
## URANIUM ENRICHMENT ACTIVITIES

**GASEOUS DIFFUSION – PLANT & CAPITAL EQUIPMENT**

| | | (DOLLARS IN THOUSANDS) | |
|---|---|---|---|
| | PROJECT NUMBER | TOTAL ESTIMATED COST | FY 1982 OBLIGATIONS |
| **PLANT** | | | |
| GENERAL PLANT PROJECTS | 82-R-410 | $ 17,500 | $ 17,500 |
| $UF_6$ CYLINDERS & STORAGE YARDS | 82-R-411 | 11,000 | 11,000 |
| COOLING TOWER MODIFICATIONS | 82-R-412 | 10,000 | 8,000 |
| IMPROVED $UF_6$ CONTAINMENT | 82-R-413 | 39,000 | 7,100 |
| PURGE & CASCADE WITHDRAWAL MODIFICATIONS | 82-R-414 | 9,000 | 9,000 |
| FIRE ALARM SYSTEM REPLACEMENT | 82-R-415 | 19,000 | 4,700 |
| ENVIRONMENTAL PROTECTION & SAFETY MODIFICATIONS, PHASE II | 82-R-416 | 16,000 | 2,000 |
| AIR DISTRIBUTION SYSTEM UPGRADING | 82-R-417 | 2,700 | 2,700 |
| PRIOR YEAR PROJECTS REQUIRING FY 1982 APPROPRIATIONS | | | 45,600 |
| SUBTOTAL – PLANT | | | 107,600 |
| **CAPITAL EQUIPMENT** | | | 23,600 |
| TOTAL GASEOUS DIFFUSION – PLANT & CAPITAL EQUIPMENT | | | $131,200 |

CHART 9

FY 1982 CONGRESSIONAL BUDGET REQUEST

## URANIUM ENRICHMENT ACTIVITIES

**GAS CENTRIFUGE – PLANT & CAPITAL EQUIPMENT**

(DOLLARS IN THOUSANDS)

| | PROJECT NUMBER | TOTAL ESTIMATED COST | FY 1982 OBLIGATIONS |
|---|---|---|---|
| **PLANT** | | | |
| ADVANCED CENTRIFUGE TEST FACILITIES | 82-R-418 | $ 25,000 | $ 6,000 |
| ENRICHED URANIUM PRODUCTION FACILITIES, PORTSMOUTH, OHIO (GAS CENTRIFUGE ENRICHMENT PLANT | 76-8-g | 1,620,845* | 669,000 |
| **CAPITAL EQUIPMENT** | | | 3,600 |
| TOTAL GAS CENTRIFUGE – PLANT & CAPITAL EQUIPMENT | | | $678,600 |

*AUTHORIZATION REQUESTED TO DATE. TOTAL LINE ITEM PROJECT COST IS CURRENTLY ESTIMATED AT $6,400,000,000 IN FY 1982 DOLLARS, ASSUMING PROJECT COMPLETION IN FY 1994.

CHART 10

## SEPARATIVE WORK CONTAINED IN THE DOE LOW ENRICHED URANIUM INVENTORY

(1/81 DOE OPERATING PLAN)

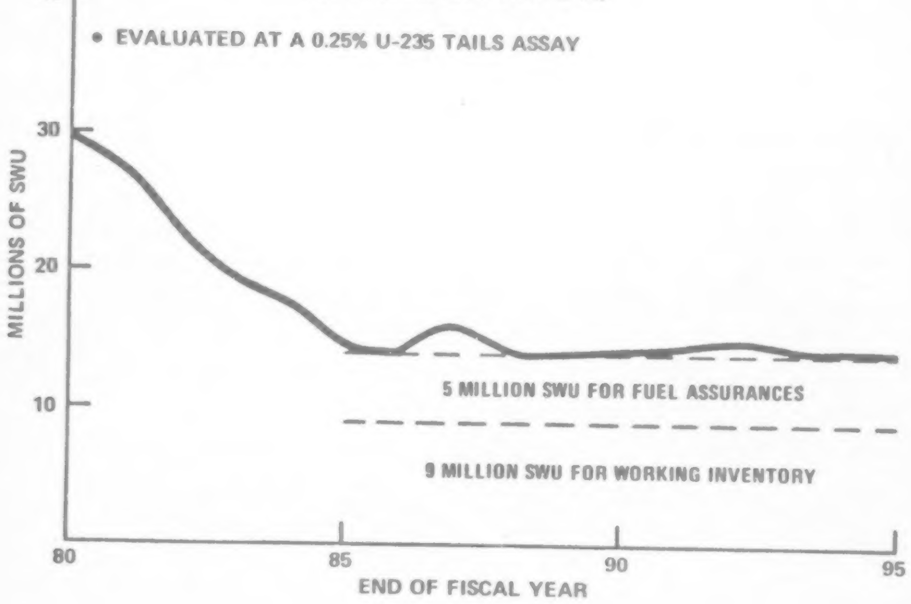


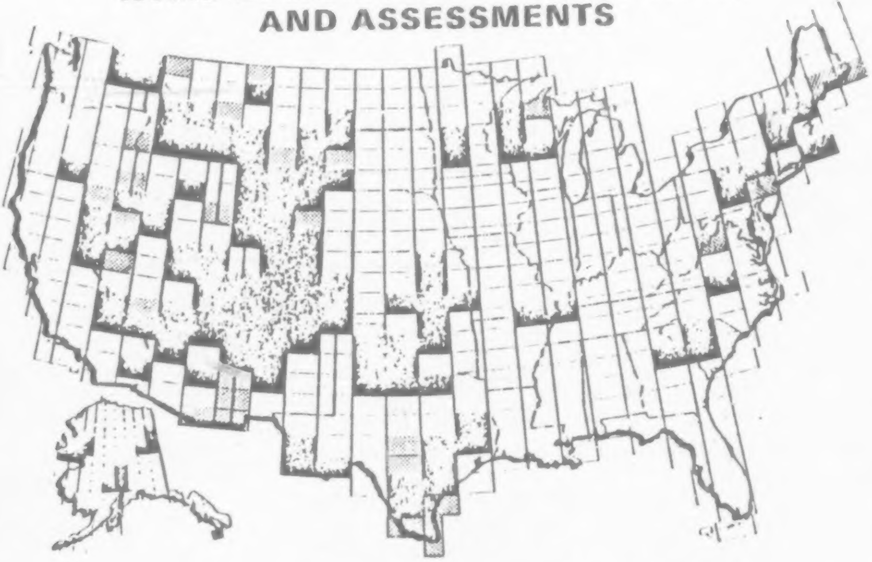
CHART 11

## FY 1982 CONGRESSIONAL BUDGET REQUEST
## URANIUM RESOURCE ASSESSMENT

| | BUDGET AUTHORITY (DOLLARS IN THOUSANDS) | |
|---|---|---|
| | FY 1981 | FY 1982 |
| OPERATING EXPENSES: | | |
| ASSESSMENT PROGRAM | $24,625 | $5,500 |
| RESOURCE INVESTIGATIONS | 16,325 | |
| TECHNOLOGY APPLICATIONS | 3,800 | |
| SUPPORTING SERVICES | 4,000 | |
| INTERNATIONAL ACTIVITIES | 500 | |
| PROGRAM DIRECTION | 4,830 | 4,200 |
| TOTAL OPERATING EXPENSES | 29,455 | 9,700 |
| CAPITAL EQUIPMENT | 500 | 200 |
| PLANT | 800 | 100 |
| TOTAL URANIUM RESOURCE ASSESSMENT | $30,755 | $10,000 |

CHART 12

## NTMS QUADRANGLE EVALUATIONS AND ASSESSMENTS



▨ 135 quadrangles completed FY 1979-80

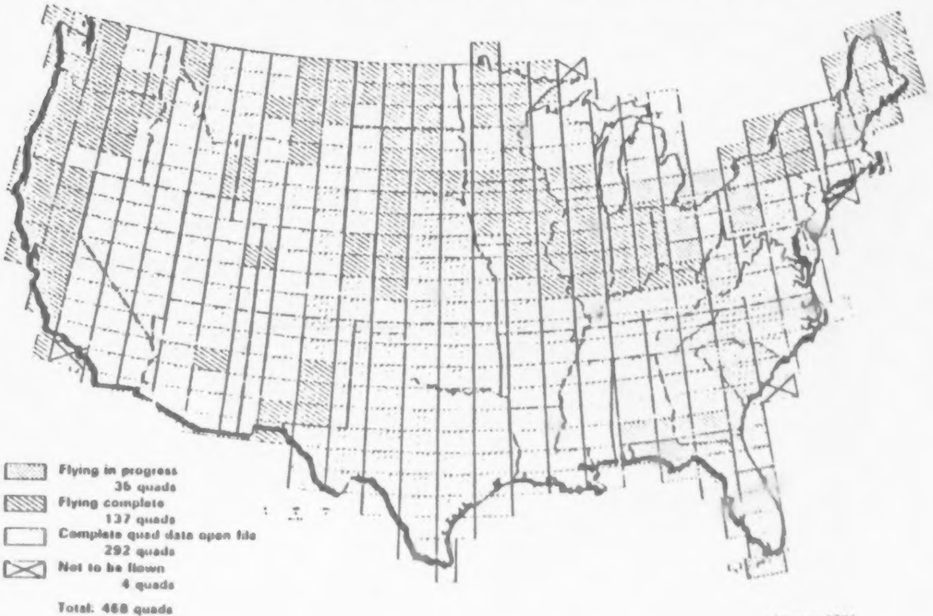
☐ 27 quadrangles to be completed in FY 1981

Total 162 quadrangles

January 1981

CHART 13

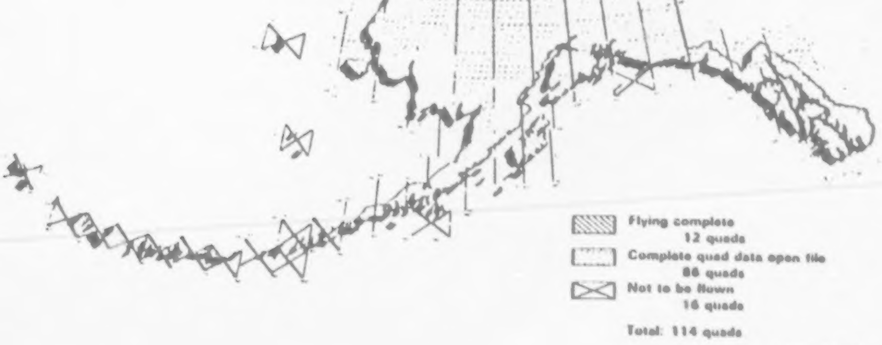
## STATUS
## AERIAL RADIOMETRIC SURVEY PROGRAM


Flying in progress
35 quads
Flying complete
137 quads
Complete quad data open file
292 quads
Not to be flown
4 quads
Total: 468 quads

January 1981

CHART 14

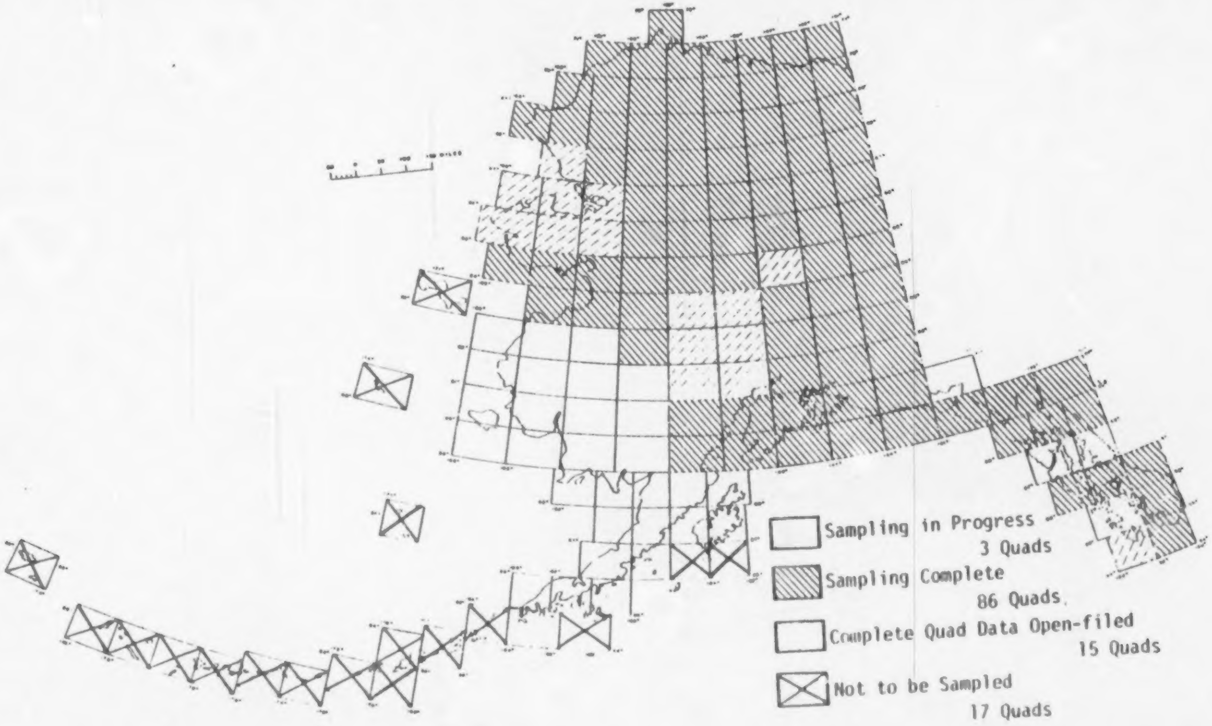
## STATUS
## AERIAL RADIOMETRIC SURVEY PROGRAM


Flying complete
12 quads
Complete quad data open file
86 quads
Not to be flown
16 quads
Total: 114 quads

January 1981

CHART 16

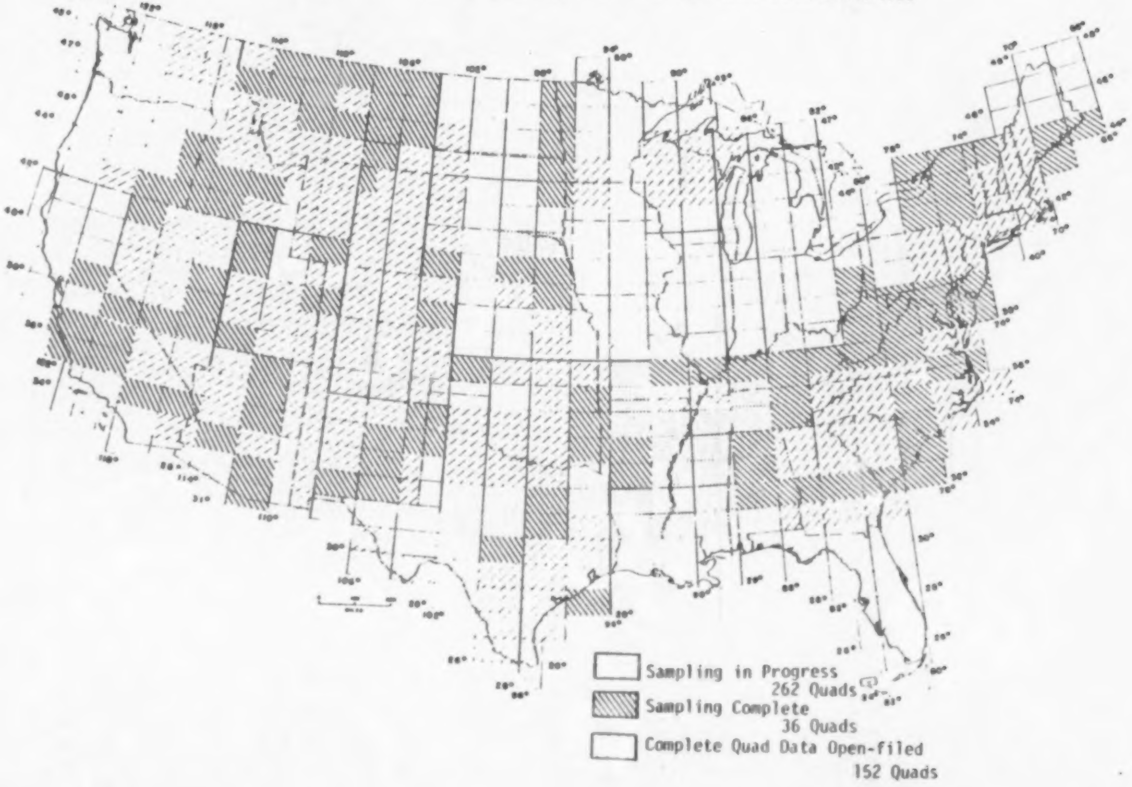
## STATUS HYDROGEOCHEMICAL PROGRAM


Sampling in Progress
3 Quads
Sampling Complete
86 Quads.
Complete Quad Data Open-filed
15 Quads
Not to be Sampled
17 Quads

As of February 1, 1981

CHART 15

## STATUS HYDROGEOCHEMICAL PROGRAM


☐ Sampling in Progress 262 Quads
▨ Sampling Complete 36 Quads
☐ Complete Quad Data Open-filed 152 Quads

As of February 1, 1981

## CHART 17

## URANIUM RESOURCES OF THE UNITED STATES[1/]

Reserves as of January 1, 1980
Other Resources as of October 1, 1980
Tons $U_3O_8$
Probability distribution values

| Forward-cost category | Mean | 95th percentile[2/] | 5th percentile[2/] |
|---|---|---|---|
| $15/lb $U_3O_8$ | | | |
| Reserves | 225,000 | 190,000[3/] | 260,000[3/] |
| Probable | 295,000 | 185,000 | 448,000 |
| Possible | 87,000 | 42,000 | 156,000 |
| Speculative | 74,000 | 30,000 | 162,000 |
| Totals | 681,000 | 447,000 | 1,026,000 |
| $30/lb $U_3O_8$[4/] | | | |
| Reserves | 645,000 | 567,000 | 729,000 |
| Probable | 885,000 | 659,000 | 1,161,000 |
| Possible | 346,000 | 194,000 | 530,000 |
| Speculative | 311,000 | 155,000 | 600,000 |
| Totals | 2,187,000 | 1,731,000 | 2,748,000 |
| $50/lb $U_3O_8$[4/] | | | |
| Reserves | 936,000 | 821,000 | 1,060,000 |
| Probable | 1,426,000 | 1,102,000 | 1,802,000 |
| Possible | 641,000 | 346,000 | 973,000 |
| Speculative | 482,000 | 251,000 | 890,000 |
| Totals | 3,485,000 | 2,771,000 | 4,313,000 |
| $100/lb $U_3O_8$[4/] | | | |
| Reserves | 1,122,000 | 971,000 | 1,291,000 |
| Probable | 2,080,000 | 1,646,000 | 2,573,000 |
| Possible | 1,005,000 | 521,000 | 1,526,000 |
| Speculative | 696,000 | 378,000 | 1,225,000 |
| Totals | 4,903,000 | 3,875,000 | 6,056,000 |

[1/] Uranium resources are estimated quantities recoverable by mining. Losses due to processing may range from 5 to 15 percent.

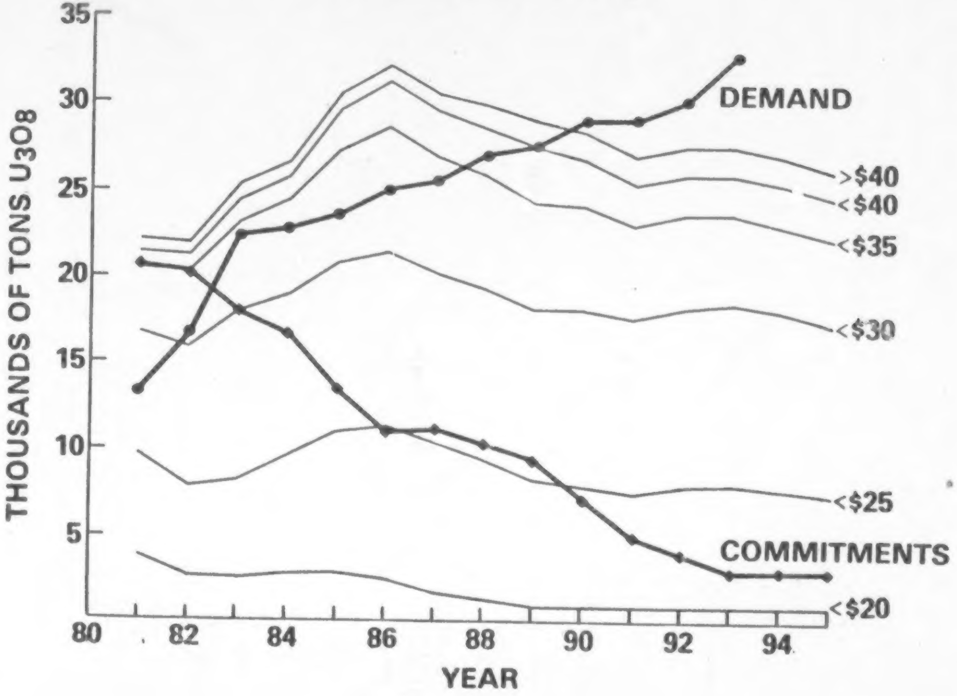
[2/] The 95th percentile indicates a 95-percent confidence in the existence of at least the amounts shown. The 5th percentile indicates a 5-percent chance of the existence of more than the amounts shown. The values for resources at the 95th and 5th percentiles are not directly additive.

[3/] The $15 category was added for purposes of this study. Confidence limits are based on an estimated ±15% confidence range.

[4/] Includes lower cost resource categories.

CHART 18

## U.S. PRODUCTION CAPABILITY BY FORWARD COST/LB $U_3O_8$ CLASSES 1 THRU 3 (RESERVES ONLY)



**Mr. Volkmer.** Thank you very much.

I now recognize the Chairwoman, Mrs. Bouquard.

**Mrs. Bouquard.** Thank you very much, Mr. Chairman.

I appreciate your participation this morning in our hearings.

Mr. Voigt, would you elaborate on the potential risks to plant reliability of continuing to run a gaseous diffusion plant at minimum capacity?

**Mr. Voigt.** I would be most happy to.

The principal concern that we have in operating the plants at low power levels during fiscal year 1981 is the fact that we have not, over extended periods of time on a continual basis, operated the plants in this manner.

However, the experience that we have had, especially during the cold winter, has been that we have not encountered any operational problems whatsoever.

There has been no barrier degradation observed.

Based on this, we have concluded that another year of operation at this power level will not affect the three plants.

However, we do have underway right now a study which would establish the minimum power level at which the three diffusion plants can be operated over an extended period of time, and we should complete that within about a year.

**Mrs. Bouquard.** What could happen to the barrier material?

**Mr. Voigt.** The problem is that when we operate at low power, we have to take diffusion plant stages off-stream.

As a result of that, we have to take out the UF6 gas that exists in these stages.

The potential that exists is that air or moisture will leak into the shut down cells and deteriorate the barrier. We also put a gas in the cells to insure that no air leaks in.

To the extent that there is leakage of moist air, this could cause barrier degradation, and hence reduce the separative efficiency of that stage.

That is the concern that we have.

**Mrs. Bouquard.** I would like a little bit of clarification on the demand charges that DOE must pay to its supplier utilities for not purchasing power at the contract level.

I understand it has risen to higher levels in recent years. Our 1981 budget number was $43 million. Now, for 1982, we have budgeted $166 million.

What is the underlying problem in not being able to negotiate a zero demand charge with the understanding the utilities could wheel the excess power to other utility systems?

**Mr. Voigt.** If the utilities were able to wheel the power to other areas, this has potential of relieving us of the demand charges. The present problem is that TVA has been unsuccessful in its ability to wheel power out of its network into surrounding networks.

This has also been true to a limited extent with EEI, as well.

Of the $43 million you mentioned in fiscal year 1981 demand charges, we were able to negotiate out of $23 million of that because some of our suppliers were able to wheel that power to other customers.

The problem has been principally with TVA.

**Mrs. Bouquard.** I can understand the problem with TVA.

The new budget recommends raising these revenues to $149 million. Since we can only recover program costs, what is the justification for raising the revenues?

Mr. VOIGT. Within the framework of full-cost recovery, there are several factors that have taken place following the original budget submission.

The first is that electricity power and interest costs have increased. Second, as I indicated in my testimony, the demand for separative work has decreased for the 10-year period used to arrive at our separative work charges. With decreased sales there are less SWU's to spread the fixed costs over and, therefore, costs per SWU and prices increases.

Mrs. BOUQUARD. For a smaller number of SWU's, you have to increase the charges to take care of your operating expenses?

Mr. VOIGT. Yes.

Mrs. BOUQUARD. We were talking yesterday, especially with Mr. Gates, that the Nation will certainly be looking to nuclear power to supply more of our energy demands than was anticipated in the past 4 years. Dr. Dillon also brought up the fact that we are going to speed up some of our licensing processes, and get more nuclear plants on line.

As I looked at your chart of projected nuclear power growth for 1995, 142 gigawatts for the United States for 1995, I don't think this quite falls into your projection. Does it, Dr. Dillon?

Dr. DILLON. Madam Chairman, it wasn't really a projection of capacity as much as a projection of potential need.

Mrs. BOUQUARD. Projection of nuclear power growth, shouldn't that follow along the line of the need?

We would be working toward the need?

Dr. DILLON. Well, certainly our programs with regard to streamlining the licensing process are focused on exactly that.

The belief that there is a need, a potential need for a great deal more nuclear power before the turn of the century, and to create an environment that will allow the utilities and the vendors to make a commercially viable business of it.

But it is not so much of what the capacity will be as what we feel the emerging need for electrical-generating capacity will be, and we certainly at this time could not project that we would have that amount of nuclear capacity on line at that time.

We are taking the steps to allow it to happen.

Mrs. BOUQUARD. These are the goals that we have.

Dr. DILLON. Yes, Madam Chairman.

Mrs. BOUQUARD. Mr. Volkmer.

Mr. VOLKMER. I would like to continue on an issue that Mrs. Bouquard brought up, and that is on the mimimum demand level for 1981. How long do you think DOE will have to operate at minimum levels?

Mr. VOIGT. We are projecting operating at those levels through fiscal year 1982, I think there is a good possibility that it will extend through fiscal year 1983, although a decision on that has not been reached.

Mr. VOLKMER. All right.

Now, the barrier problems that arise because of the minimum demand level, is it only in the gaseous diffusion operation that this occurs?

Mr. VOIGT. That is correct, sir.

Mr. VOLKMER. Once we get the centrifuge on line in the last part of this decade, will the minimum demand level have an effect on the centrifuge system as much as it does on the gaseous system?

Mr. VOIGT. Over the longer term, Mr. Chairman, we project that there is a need to power the three diffusion plants higher than the levels that we are now operating at in fiscal year 1981, as well as that we requested of Congress in 1982.

If the demand continues to erode, then there may be a requirement to consider displacement of the existing diffusion plants with the gas centrifuge process due to the economics, and the less energy-intensive nature of the centrifuge.

Mr. VOLKMER. On the demand payments that we must make at this time, it appears if we continue to have the minimum demand levels through 1982 and possibly in 1983, we are looking at the same thing in 1983 as a possibility, also, especially with TVA?

Mr. VOIGT. That is correct.

Mr. VOLKMER. The reason for the TVA problem basically is that TVA has no facilities to wheel that throughout the country to sell off that excess?

Mr. VOIGT. That is correct, sir.

Mr. VOLKMER. We do not have a similar problem with Ohio and other places, is that correct?

Mr. VOIGT. It does not appear to be as acute as with TVA.

Mr. VOLKMER. What can we do to help TVA so they can sell that excess power to other places?

Mr. VOIGT. Mr. Chairman, we would dearly love to be able to see some of this power go into Florida, to offset the oil-burning capability they have there.

Mr. VOLKMER. That makes sense.

Mr. VOIGT. The problem is transmission capability.

Mr. VOLKMER. At the present time, there is not sufficient high-voltage transmission?

Mr. VOIGT. The current lines are pretty much filled up, and hence, TVA cannot wheel additional power over them.

Mr. VOLKMER. Yes. Is it the problem between the TVA facility and Florida; in other words, there is Georgia, Alabama, or is it inside Florida?

Mr. VOIGT. Well, it is both.

It is the wheeling capability in the States surrounding Tennessee, as well as the ability of Florida to take it down to the southern part of Florida where it is most needed.

Mrs. BOUQUARD. I think there are also certain restrictions within the TVA Act, are there not, that restricts them?

Mr. VOIGT. That is correct.

Mrs. BOUQUARD. Thank you.

Mr. VOLKMER. If we corrected that, we would still have transmission problems?

Mr. VOIGT. We would still have the transmission capability problems that I mentioned, yes, sir.

Mr. VOLKMER. In regard to the centrifuge program, would it be possible to give us an approximation, of the actual savings over the gaseous diffusion system?

Mr. VOIGT. Yes, sir.

Mr. VOLKMER. By 1990, for example?

Mr. VOIGT. Yes, sir, to the extent, as I mentioned earlier, that a given demand exists, our economic analysis indicates that it is very cost-effective to displace the very power-intensive diffusion plants with the gas centrifuge.

The gas centrifuge only uses 5 percent of the equivalent amount of energy that a diffusion plant uses. To put that into perspective, Mr. Chairman, for 8.8 million separative work units, it takes about 2,700 megawatts for a diffusion plant.

For a centrifuge plant, it only takes 135 megawatts for 8.8 million SWU of capacity.

So from that standpoint, you are relieved of a lot of the power requirements that you would have had, had you kept the diffusion plant in operation.

Mr. VOLKMER. As far as our demands for need for enrichment uranium by 1989, 1990, when will we actually have a reliable date?

Will it be 1985, 1986, because I am sure a lot depends on what else we do in the nuclear energy area?

Mr. VOIGT. A crucial element is what we do in the whole nuclear energy option.

I would be hopeful that within the next several years, say within the next 3, that we would see a stabilization and a possible upgrowth in nuclear power.

Mr. VOLKMER. Dr. Dillon, do you have anything?

Dr. DILLON. I certainly agree.

Mr. VOLKMER. One relates to the other.

Dr. DILLON. The concern we have is that to get the nuclear powerplants we think we are going to need between 1995 and 2000, we are going to need to see ordering begin in the not-too-distant future.

We need to get things stabilized in the next 3 or 4 years to where ordering of nuclear powerplants will resume.

So I agree that that is the time frame we are looking at.

Mr. VOLKMER. I know that may not be exactly in your field. I personally feel while we are looking at this issue, we should also look at siting plants near where the demand is.

I am not advocating locating them in cities, but as to the demand factor, instead of wheeling and losing energy, we could try to locate the plants where the need for them occurs. Is anybody looking at that?

Dr. DILLON. We in our program will be looking at siting from a general point of view including that dimension.

Mr. VOLKMER. Now, industry, energy availability, population growth, and those types of parameters?

Dr. DILLON. That is a major consideration that any industry has when it sites—what will be the availability of electrical energy in that district. That is becoming a major factor, I think, in industry decisions on where to locate.

One of the incentives that we think we need to try to sell to the public utility commissions is their ability to attract new industry and economic development to their region, based on having reliable and assured amounts of electricity.

Mr. VOLKMER. I will now return the chair and the questioning to Mrs. Bouquard.

Personally, I want to thank all of you.

Mrs. BOUQUARD. I have one or two more questions on enrichment before we go on to our advanced nuclear systems.

How many gigawatts, how many SWU's do we need to take care of a nuclear plant to get 1-gigawatt production?

Mr. VOIGT. For the initial core, it takes on the order of 250,000 SWU's, and about 120,000 SWU's per reload.

Mrs. BOUQUARD. That is basically for the first core?

Mr. VOIGT. The first core is of the order of 250,000 SWU's. For subsequent reloads, about 120,000 SWU's.

Mrs. BOUQUARD. We are talking about 27.1 million SWU's by 1995, is that correct?

Mr. VOIGT. Yes; for diffusion capacity. With GCEP it will be about 36 million SWU's.

Mrs. BOUQUARD. How many gigawatt plants will this accommodate is what I am trying to get at?

How many plants are we working toward for 1995, Bill?

Mr. VOIGT. In terms of our current projections, we are talking about 231 gigawatts.

Mrs. BOUQUARD. OK.

Mr. VOIGT. Being supplied by us in 1995.

Mrs. BOUQUARD. And this is for our domestic needs?

Mr. VOIGT. What?

Mrs. BOUQUARD. That includes our domestic and foreign commitments?

Mr. VOIGT. It is both domestic and foreign.

Mrs. BOUQUARD. Is there any reliable information on how many plants our competitors will support?

Mr. VOIGT. The current planning of our competitors is such that for the EURODIF plants on line by 1985, 10 million SWU's.

URENCO is expected to have on line in the same time frame, 1985, 2 million SWU's.

The Soviet Union is now supplying on the order of 3 million SWU's per year. This is not their total capability, but this is what they are contracting for.

There are other people who are planning to come into the enrichment business. For example, the Japanese, currently plan to have 1 million SWU's on line in 1990.

The other two, South Africa and Brazil, are somewhat uncertain, but they are considering 250,000 SWU's for both countries, also on line by 1990.

Mrs. BOUQUARD. In view of the fact that we are looking for the nonproliferation policy to take a different approach, what are we really doing to go out and to look for new customers for our enrichment services?

Has anything been done? Any plans to move in this direction?

Mr. VOIGT. Yes, indeed.

We have a very intensive marketing effort which has been going on for about over a year now.

In fact, I just came back myself about 5 months ago from a trip to Japan and South Korea.

Right now it appears the marketplace will be in the Far East. The nearest short-term market being in Taiwan.

Mrs. BOUQUARD. How about Australia?

Mr. VOIGT. Australia is considering the building of an enrichment plant within the framework of trying to add added value to their vast natural uranium holdings.

They want to export uranium in an upgraded form.

Mrs. BOUQUARD. When I first came to Congress in 1975, and I went to Oak Ridge, it seems to me one of the things we stressed is that we were supplying international markets.

This was one of the big things that was stressed to me, and now all we are talking about is our domestic needs.

Mr. VOIGT. We are attempting to get as much of the foreign market as we can.

Mrs. BOUQUARD. I certainly hope that we will move in that direction.

Isn't our centifuge technology really a superior technology?

Mr. VOIGT. It is superior to the technology, as we know it today, to that being used by URENCO.

Mrs. BOUQUARD. We have had several estimates, but you can reliably say that most of the estimates say we need on line by the year 2000 about 300, 350 plants.

Is that not so, Dr. Dillon?

Dr. DILLON. Yes.

Mrs. BOUQUARD. We are saying right now that we are providing for capacity for 231. Which way are we going? I am not being critical. I am asking if we are really looking at all our estimates and get our minds working in the same direction.

Are we going to increase our capacity for more nuclear plants or are we committing ourselves to 231 plants?

Dr. DILLON. I think in general the administration is looking at the regulatory process and, in terms of the supporting research and development that we are responsible for, is doing everything possible to secure the amount of nuclear capacity we need.

As I said, we have looked at analyses making certain assumptions about economic growth and the increased electric fraction and it seems to indicate we are going to need a considerable amount of nuclear power. That is the thrust of all our programs.

With regard to enrichment, that is one of the principal reasons for the advanced isotope separation program.

If we are successful over the next 3 or 4 years of creating an improved environment, we do see a resource pattern of new nuclear capacity, then we will have the capability to respond accordingly and provide for that needed capacity enrichment and every other aspect of the technology.

Mr. VOIGT. Our capability to expand centrifuge capacity requires a leadtime of about 6 six years. A nuclear powerplant right now takes on the order of 12 years. Hopefully, that will be shortened considerably, but since we have the capability of adding enrichment capacity on a shorter time schedule than nuclear powerplants, we believe we can respond to any increased demand for enrichment services.

Mrs. **Bouquard**. Then all our panelists are agreed that our capacity is on line to provide for the present orders and the present demand capacity?

Mr. **Gates**. Yes.

Mrs. **Bouquard**. Thank you very much. Are you saying that we can increase our capacity for enrichment to accommodate plants through 1995?

Mr. **Gates**. I think the capability for providing SWU's is consistent with the projections for the requirement for SWU's and the number of reactors that would be on line at that time.

Mrs. **Bouquard**. Thank you very much.

Do you have any more questions?

Mr. **Volkmer**. Yes, I do have a few more questions. I would like to ask about the space-related activities and the funding of those. What I would like to know is what is the rationale for funding these activities in the DOE budget rather than in the NASA and DOD budgets?

Dr. **Dillon**. We do get reimbursed from NASA and DOD for other than first-of-a-kind flight hardware.

Mr. **Volkmer**. Why don't we turn it over to NASA and let them do the whole thing?

Dr. **Dillon**. The development activities and the first-of-a-kind activities have been funded by DOE. I think there is a very good reason for that and a good reason to continue that.

There is actually a very sophisticated and very unique production facility that lies behind our ability to have these thermoelectric generators.

The special isotope is produced in our DOE production facilities at Savannah River and it is fabricated and formed in a special facility, a plutonium fuel form facility.

These facilities represent a unique capability and they are part of the DOE complex.

The base program funding really needs to continue with the Department of Energy so that we can properly manage and plan for those development activities.

Developmental activities need to bridge over the peaks and valleys of the specific flight requirements. That is the rationale, and why it is jointly funded.

Mr. **Volkmer**. You don't foresee any difficulties in reimbursement from DOD and NASA on that?

Dr. **Dillon**. No. One of our strategies is to work toward a relatively larger fraction being reimbursed.

Mr. **Volkmer**. Does reimbursement include the cost of the Savannah operation?

Dr. **Dillon**. Only for those parts related to the specific flight units.

Mr. **Volkmer**. But not to the overall capitalization factor?

Dr. **Dillon**. No, and not to the developmental costs associated with it.

Mr. **Volkmer**. I would like to go back for just a few minutes to the subject of enrichment to get some idea of where we are in relation to other countries. Japan and Australia are building enrichment capacity or planning to do so. Mexico is talking about buying nuclear powerplants—not from us, it looks like. Who will do the enrichment? That is what I am wondering about. Will France do that also?

Mr. **Voigt**. The two existing units in Mexico, the Laguna Verde No. 1 and 2, do have contracts with us.

We are trying to convince them that they should sign up with us in the future when they consider building nuclear powerplants.

Mr. **Volkmer**. In other words, there are negotiations and discussions like that ongoing?

Mr. **Voigt**. Yes, indeed. It is also fair to say that our competitors, EURODIF and URENCO, are down there talking to them as well.

Mr. **Volkmer**. Right now our cost for enrichment is considerably less?

Mr. **Voigt**. Yes. However, I just found out this morning EURODIF's nonpartner price is now $134 per SWU. That is close to our existing price.

As we bring on the gas centrifuge and the advanced isotopic separation processes, we are talking about future prices substantially below this. Hence, it is hopeful we can still compete with a wide margin between ourselves and our competitors.

Mr. **Volkmer**. What technology do you envision will be used by the other countries like Japan and Australia?

Do you have any idea?

Mr. **Voigt**. Japan is pursuing the gas centrifuge as the process for enrichment. Australia has not made a decision as to what technology they will deploy.

From discussions I have had thus far it appears they favor the centrifuge process as well.

Mr. **Volkmer**. If those plants are constructed with our suppliers, production people, et cetera, will they produce most of them for that?

Mr. **Voigt**. The one thing——

Mr. **Volkmer**. In other words, can we export this technology?

Mr. **Voigt**. Mr. Volkmer——

Mr. **Volkmer**. Let it go. We will just wait and see.

Thank you, Madam Chairman.

Mrs. **Bouquard**. Thank you very much, Mr. Volkmer.

Dr. Coffman, I would like to go back to Mr. Volkmer's questions on the space-related activities funded through the DOE budget rather than providing it through a combination of the NASA and DOD budgets.

I understand that we are reimbursed for the construction work but how much of the $38 million in budget authority will we really be reimbursed for?

Mr. **Coffman**. The $30 million is totally DOE funded to support the Galileo and the Solar Polar missions. Along with that there is a NASA program which funds the auxiliary equipment and there is also a program of interagency funding transfer which includes approximately $20 million of NASA funding for the Galileo and Solar Polar mission.

So a substantial portion of the costs vis-a-vis the base research and development costs up to the point of the first preprototype is borne by DOE funding through this committee.

In the case of Galileo and Solar Polar, I think there are five thermoelectric generators. We will build and fund for the first preprototype and then through interagency funding transfers the cost will be borne by NASA for the production units.

Mrs. BOUQUARD. We pay for all the engineering and the qualifying part of the basic programs.

Mr. COFFMAN. That is correct. We pay for the base research and development prior to the explicit mission requirements.

Mrs. BOUQUARD. In other words, we pay for the $38 million that is in fact in our budget authority?

Mr. COFFMAN. Yes.

Mrs. BOUQUARD. Why should DOE pay for anything that only NASA and DOD benefit from? I think they are fine programs, but I am objecting to the budget authority in the DOE budget.

Mr. COFFMAN. The program that is in place as Tom explained, resides within the nuclear materials production complex, hence, the origin of the management of it.

I think the history of the DOE funding, of course, goes all the way back to the NERVA program and the relationships that were developed there.

My personal opinion, the reason some semblance of a base program is maintained is because of the multiple mission aspects. In other words, there are Department of Defense applications; there are certain terrestrial applications as well as the two NASA missions that were mentioned.

I think it is on that basis that there is a base program to maintain that.

If the program generically, independent of who managed it, were strictly tied to similar missions, I think the discontinuities associated with trying to maintain would be rather disruptive.

I think that was the logic behind it but we will be happy to reexamine that and provide a much greater analysis for that.

Mrs. BOUQUARD. I think that might be a worthwhile activity for this Congress.

We welcome our students to our hearing this morning and without objection, we will permit photographs at this session.

Mr. Volkmer.

Mr. VOLKMER. For the record, I would like to have that information. I think I know the answer but I would like to have it.

Mr. Voigt, what do you figure are the costs to the consumers for the purchase of electricity? Is it just the operating costs, raw materials plus operating costs and salaries, et cetera, or do we have amortization factors, depreciation factors built in on the accounting of the plan and the costs also?

Mr. VOIGT. Yes, sir; we include the amortization of the facilities, all the direct operating costs, overhead, like my salary which makes up a very small amount of the charge so all factors are included.

Mr. VOLKMER. It is all basically in there. What I am primarily interested in is the amortization costs. What are the amortization costs on the present three facilities?

Mr. VOIGT. The facilities are amortized over a 25-year period.

Mr. VOLKMER. Which is normal.

Mr. VOIGT. However, the net book value of the three diffusion plants right now is about $1.6 billion including the Cascade improvement and uprating programs.

Mr. VOLKMER. Some of that has probably been amortized out already.

Mr. VOIGT. That is correct.

Mr. VOLKMER. Thank you very much.

Mrs. BOUQUARD. Dr. Coffman, what is the function of the plutonium fuel form facilities that the administration is proposing to defer and what will the effect of this deferral have on the program?

Mr. COFFMAN. The purpose of this facility is to allow us to proceed with the production of the thermoelectric generators for the Galileo and Solar Polar missions. These are firm missions which must be met in some manner. They are deep space missions and cannot be met through photovoltaic or other approaches so they do require the isotopic heat sources.

This is simply a part and parcel of that mission which was agreed to through the interagency agreements.

Its function basically is to fabricate the isotopic heat sources for these five thermoelectric generators.

Dr. DILLON. The administration has not proposed deferral of that facility. The facility is in operation and it is a vital part of meeting our obligations to those missions, and we are planning and budgeting for it.

Mrs. BOUQUARD. What part of Solar Polar—this is not really related to these hearings—what part of this mission are we withdrawing support from?

Dr. DILLON. There were two proposed spacecraft. One was going to be paid for by the European Space Agency and another by the United States.

The U.S. spacecraft, which would have been one of a pair that would go out of the eliptic, the plane in which all the planets exist has been dropped and so we are planning to support the European spacecraft but I don't believe the U.S. spacecraft is now funded.

Mrs. BOUQUARD. Dr. Coffman. I did think there was a $300,000 reduction in the budget for the plutonium facilities.

Mr. COFFMAN. There were several reductions, of course. In the spirit of what you were talking about regarding shared costs, the space power reactor program in terms of funding through this committee was cut in half this year, and, indeed, NASA has agreed as of this January to reimburse Los Alamos for approximately $700,000 plus another half million dollars of heat pipe research and development they were doing.

In the isotopic program there were also some reductions in particular when this one satellite was dropped, one of the six thermoelectric generators was dropped from our program so we had a reduction of approximately one-sixth in terms of the amount of plutonium and the number of electric generators we had to produce.

In association with that, there were some slight trimbacks and deferrals, but to get to the point of your interest, because of these reductions and because of cost escalations to allow us to deliver the five thermoelectric generators, we had to utilize our research and development moneys for production purposes, and this had a negative impact in terms of potential risk, but with a fixed budget mark and firm mission dates and requirements, we had to transfer 350 K out of our advanced materials research and development into actual production activities.

Mrs. **Bouquard**. Thank you very much.

In the sludge irradiation program, does the Department believe a single demonstration is really enough to prove technology of sewage sludge irradiation?

Mr. **Coffman**. The base program that we had involved a concept of perhaps five or six demonstration units. It involves instilling the confidence in municipal bodies, EPA and NRC through the actual demonstration of these facilities.

A typical sludge irradiator for a municipality for Knoxville, Tenn., for example, would cost approximately \$2½ million and would also utilize about 10 percent of the total encapsulated cesium at Hanford for beneficial use.

Our hope is that we could, through commercial enterprises, get companies such as Bechtel and others to pick these up since the paybacks on these typically run 1 to 5 years for the beneficial uses of the inactivated sludge.

Our base program at this point is to provide the basic R. & D. showing the safety through the research and to attempt to build one facility beginning in fiscal year 1982.

In that budget, subsequent demonstrations would appear in the mid-eighties at perhaps one facility per year.

Mrs. **Bouquard**. This will be used for fertilizer and feed; is that correct?

Mr. **Coffman**. Yes that is correct. In Howard County here, for instance, the sludge from municipal waste treatment plants is put into trenches. The cost of that trenching runs on the order of \$200 to \$300 per ton.

If you beneficially use that, payback for the facility occurs in about 1 to 2 years. It is a beneficial use and it avoids a loss of land use through disposal as a hazardous waste.

Mrs. **Bouquard**. Wouldn't you have a problem giving every municipalilty enough nuclear waste to prove this practicality?

Mr. **Coffman**. At present, as I said, there is enough cesium encapsulated at Hanford to supply approximatley one dozen municipalities.

The light water reactor industry is generating a similar amount of waste per year so each year that the light water reactor runs you generate enough cesium waste to supply another dozen or so municipalities.

At Savannah River there is enough to supply for 25 or 30 municipalities if that waste would be encapsulated.

Mrs. **Bouquard**. How long does this waste last?

Mr. **Coffman**. The cesium life is about 30 years. So it is a matter of decades.

Mrs. **Bouquard**. It sounds like a very promising technology.

Mr. **Coffman**. In my personal opinion, it is an economic question. Surely all of our resources should be utilized if it is an economic and safe approach to use.

I think our hope is that we would not get deeply involved but, rather, would find it is a commercial and beneficial national venture, but certainly it makes sense to recycle our products and avoid retaining them as a hazardous waste but, rather, as a beneficial product.

Mrs. **Bouquard**. In instilling more public confidence, does the Department feel pathogens in the sewage will be destroyed by radiation?

Mr. **Coffman**. Yes.

In the last few months, for example, the IEA and internatonal bodies have agreed that in radiation of food products at the 100 kilorad level or less is completely harmless and they granted a blanket use of irradiation for food preservation and lengthening of shelf life.

The experiments on the sludge that have been done indicate, and EPA is willing to grant use of this as a fertilizer, use of food chain crops and, of course, the more mundane applications of golf courses in high land use areas.

It is my opinion that is simply not a problem.

Mrs. **Bouquard**. And there are no other harmful effects foreseeable?

Mr. **Coffman**. All sludges have the potential for heavy metals, so clearly you would have to sample and be assured that there is not a toxic chemical pollutant that is going into our sewage treatment plants.

There is a control at the source program and a major portion of the municipal sludge is satisfactory for this application but surely you do have to take precautions.

Mrs. **Bouquard**. Thank you very much.

I have no further questions. I appreciate you being here at an early hour for our hearings and your participation and your testimony.

We will resume our meetings next Tuesday, March 24, at 8 o'clock in the morning.

This is our markup session on our DOE fiscal year 1982 budget authorization.

If there are no further questions or remarks, the subcommittee stands adjourned.

[Whereupon, at 10:25 a.m., the subcommittee was adjourned.]

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